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Biological Sciences

This conference, held in March 1987, focused on research in biosensors and environmental biotechnology. Topics summarized in this report include development and applications of novel biosensors, biosensors based on thermistors and semiconductors, gaseous chemical diagnostics, biosensors for food analysis, and biosorbent materials for metal recovery.

Computer Sciences

The Cellular Logic Image Processor, originally developed in the 1950's by University College, London, has been updated over time with a succession of these parallel processing systems. CLIP4, the current evolutionary system, is believed to be the fastest existing system for image processing, and CLIP7 is now in the planning stage at University College. CLIP4 is described in some detail.

Material Sciences

A selection of some of the research in electronic ceramics at the Hebrew University of Jerusalem, Technion-Israel Institute of Technology, and Tel-Aviv University is reviewed. The work at these institutions is judged to be of high quality, and the many scientists there are addressing important problems in electronic ceramics.

The emphasis of this report on the Harwell Laboratory of the UK Atomic Energy Authority is on the R&D work in semiconductor gas sensors. The author concludes that the Harwell people are demonstrating that basic research, applied research, and device development are not incompatible endeavors and that all three benefit from the interactions generated within the same group.

Mechanics

The presentations at this meeting in Bristol, UK, in April 1987 were given in five different sessions: facilities, experimental investigations and techniques, propulsion, viscous flows, and vehicles and design. Selected presentations from these sessions are reviewed.

Topics of presentations at this meeting, held in March 1987 at Cambridge, UK, included turbulence studied from the Lagrangian point of view, calculation of mixing and combustion, experimental work in turbulence structure, and modeling. The presentations are reviewed.

Ocean Sciences

The author visited establishments connected with the universities of Bergen, Oslo, and Tromso as well as the Nansen Institute and the Norske Veritas Company. He reports that the quantity and quality of the oceanographic work being done is impressive, particularly in areas of direct interest to Norway such as those related to ice, polar studies in general, and fjords.

Marine Science work and facilities at institutions in Haifa, Tel Aviv, and Jerusalem are discussed. The author concludes that for a small country such as Israel the amount of active research, its quality, and the wide diversity of fields it covers is exceptional.

Physics

A research group at the Institute for Fundamental Physics, Autonomous University of Madrid, makes great strides in both the basic understanding and in unusual applications of scanning tunneling microscopy. Current and planned equipment is described, and two research projects with electrochemistry in mind are reviewed as an example.

Professor T.W. Hänsch, after 16 years at Stanford, returned to his native Germany and is in the process of building up two super-labs (one at Munich University, one at the Quantum Optics Institute at Garching). Combination of ultrahigh-resolution laser spectroscopy with scanning tunneling microscopy will explore unchartered domains of atomic physics. Other research will focus on further improving the accuracy (by the use of laser spectroscopy) of our knowledge of fundamental atomic constants and the subtle details of quantum-electrodynamics, including the study of excited anti-hydrogen.

News and Notes

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Biological Sciences

BIOTECH '87 FOCUSES ON BIOSENSORS AND ENVIORNMENTAL BIOTECHNOLOGY

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1988 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

The International Conference and Exhibition for Bio- and Gene Technology (Biotech'87) was held at the conference center in Düsseldorf, West Germany, from 17 through 19 March 1987. There were 200 participants at the meeting, 80 percent of them from industrial organizations and 20 percent from universities and research institutes. Although the majority of participants were from West Germany, 20 European countries were represented. In addition, there were attendees not only from Western Europe but from East Germany, Poland, Czechoslovakia, Hungary, and the USSR as well as Canada, the US, Turkey, and Japan.

The focus of the conference was on two areas of biotechnology research, namely, biosensors and environmental biotechnology. The topics covered under the biosensors section were:

- Development and application of novel biosensors
- Biosensors based on thermistors and semiconductors
- Gaseous-media biosensors
- Trends in biosensor technology
- Development of DNA probes for clinical diagnostics
- Biosensor systems for food analysis
- Enzyme electrodes in bioprocessing
- Electric monitoring of cell behavior in culture.

The section on environmental biotechnology included the following topics:

- Aeration systems for aerobic wastewater treatment
- Development of novel catabolic pathways
- Degradation of halogenated hydrocarbons
- Anerobic treatment of wastewater from the pulp and paper industry
- Fluidized bed reactors in anerobic wastewater treatment
- High solids anerobic digestion
- Microbial degradation of problematic exhaust air components
- Technical systems for biological treatment of exhaust air
- Biosorbent material for metal recovery.

The exhibition area was quite extensive and included exhibits of products and equipment from European as well as US industrial organizations.

A summary of selected topics presented at this conference emphasizing primarily research on biosensors is presented in this report.

Biosensors: The Future Has Already Started

Biosensors have gradually emerged from science fiction fantasy and come to market reality. Especially Japanese and US as well as some European companies are developing, producing, or already marketing biosensors; those marketing biosensors include Amersham International, Cambridge Life Sciences, and Harwell (for Harwell's semiconductor gas sensor work, see page 427) in the UK and the Pharmacia affiliate, Biosensor, in Sweden.

Application of these sensors ranges from the detection of substances in the blood serum (tumor antigens or glucose, for example) or the analysis of food components to fermentation control or environmental monitoring. Biosensors have been developed for the determination of urea, penicillin, amino acids, glucose, lactate, galactose, sucrose, alcohol, and others. In particular, biosensors will be involved in human health care and veterinary medicine where metabolites, hormones, drugs, or toxins will be detected or physiological functions monitored. The pharmaceutical industry will probably apply biosensors in production process control or as an alternative for animal uses in testing. The biosensors will be used in agriculture for the detection of pesticides as well as for quality control. Detection of the pesticides will also be important in environmental protection in addition to detection of other contaminants.

What is biological in a biosensor? Its biology lies hidden in the detector--i.e., that part of a sensor which is in touch with the substances to be detected or with the environment to be monitored. The concerned biological material may be enzymes, microorganisms such as bacteria, monoclonal antibodies, or whole cells or parts thereof. These must be fixed to

the surface of the detector's carrier material. This requires thorough knowledge of immobilization techniques, surface chemistry, biocompatability of materials, etc. Also, it must be ensured that the reaction which the biological material will exhibit in the presence of the substance to be analyzed will be converted into an analog or digital signal via another part of the sensor, the transducer. Correspondingly, the transducer will be formed by more conventional electronic or optoelectronic devices or other suitable technical systems. These technical systems are developing towards better precision and miniaturization. Especially the latter aspect makes field effect transistors most suited as transducers in biosensors.

The advantages of biosensors are their high selectivity combined with high sensitivity plus the fact that they work without reagents and even in turbid media. In addition, biosensors exhibit great potential for miniaturization and computer compatability, thereby facilitating process control and data analysis. Figure 1 is a diagram showing how the new biosensors work.

Development and Applications of Novel Biosensors

An overview of biosensor technology including some examples of biosensors developed in his laboratory was presented by I.J. Higgins (Cranfield Biotechnology Center, Cranfield Insitute of Technology, Cranford, UK).

Most biosensors which are currently commercially available are amperometric enzyme electrodes, characteristically representing the key recognition and transduction element of a laboratory instrument. These devices are fairly complex and relatively expensive, primarily due to the technical mechanisms necessary to adapt the properties of the particular enzyme used to the demands of practical chemical analysis. These first-generation biosensors are primarily used for analysis for medical, military, food, and fermentation applications. According to Higgins, the total existing world market may be as much as $50 million per annum, the exact figure being difficult to assess accurately due to the lack of availability of figures for military use. Higgins stated that there is enormous potential for exploiting the remarkable chemical recognition properties of biological systems in a wide range of analytical devices from cheap, hand-held, user-friendly, pocket instruments to compact, desk-top, multiple sensors. The existing world analytical market is about $2 billion per annum and could be considerably expanded by developments leading to generally available devices which can be used by the nonspecialist, and which give rapid, accurate analytical information. This requires technological advances which will involve developments of

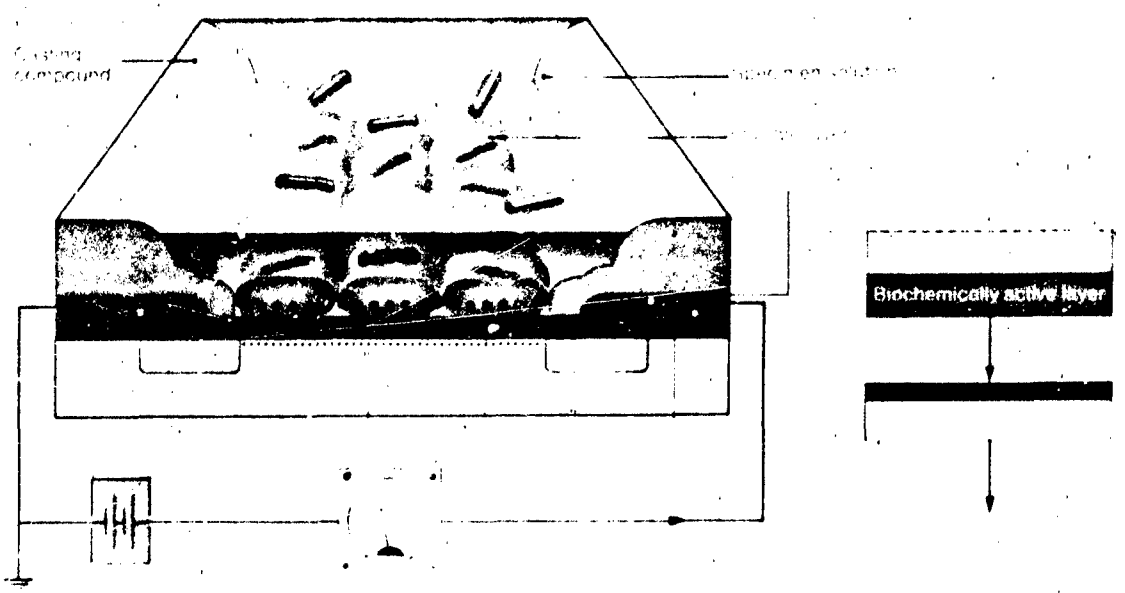

Figure 1. How the new biosensors work.

existing enzyme electrode technology as well as alternative approaches using modern optical methods in association with biological elements.

Higgins focused his talk upon recent developments in amperometric electrodes, some of which have already enabled the development of miniature, cheap, specific, user-friendly, second-generation biosensors which out-perform expensive first-generation analyzers. According to Higgins, their use for medical applications is expected to become widespread over the next few years. These new developments have been made possible by studies of protein electrochemistry which have led to the discovery of methods allowing intimate links between enzymes and conductors. Techniques have been developed to modify the properties of appropriate enzymes (especially oxidases) in sensor configurations so that the overall kinetics are more appropriate for the analytical needs, stability is improved, and the electron acceptor is not oxygen but a conductor. For example, several low-molecular weight mediators such as derivatives of ferrocene can be incorporated together with oxidase enzymes into extremely simple, small, thin-layer carbon electrodes, giving accurate, stable sensors for a range of important analytes. In addition, these low-potential electrodes can easily be configured to operate in complex chemical environments such as meat, blood, tissue, food, and fermentation media.

More recently, these new amperometric approaches are being used to develop simple, rapid, immunosensors using amperometric enzyme links to detect antigen-antibody binding. For example, it is possible to detect alkaline phosphatase-labeled material (commonly used in immunoassay) by employing novel substrates for this amperometric enzyme which generate a new electrochemical signal upon removal of the phosphate group by the enzyme. Configurations can be envisaged which can lead to the development of simple, rapid, even single-step immunodiagnostics based on enzyme electrode technology. Higgins stated that this may well also prove to be true for the development of DNA-probe sensors. At the present time, the use of amperometric approaches for the development of immunosensors and DNA-probe sensors requires further research for a marketable system. Several laboratories in the US, Japan, and Europe as well as Higgins' laboratory are actively engaged in research in this area.

Higgins and his group are also currently investigating a range of nonmedical applications of the basic mediated amperometric enzyme electrode technology. These include multiple glucose sensors and lactate sensors for rapid meat quality control assessment and extremely rapid biomass sensors (response time, less than 1 minute) for use in a wide range of samples based on similar technology. Higgins stated that much remains to be done in reducing some of these ideas to commercial practice.

In addition, further opportunities will arise via the development of even closer links between the biological element and the electrode as well as by the use of multiple enzymes in amperometric electrodes, especially for amplification purposes.

Biosensors Based on Thermistors and Semiconductors

Biotechnological processes need to be monitored very accurately and checked constantly. The slightest deviation in temperature of the heat of reaction can be of decisive importance for the entire process, such as in fermentation. Biosensors based on enzyme thermistors are especially sensitive calorimetric "watchdogs." B. Danielson (Faculty of Pure and Applied Biochemistry, Chemical Center, University of Lund, Sweden), who addressed this subject, is currently working on development of enzyme thermistors and enzyme transitors for process control in clinical chemistry and in biotechnology.

Calorimetry is a technique with general application in bioanalysis. The enzyme thermistor (ET) is a simple flow calorimeter developed by Danielson and his group at the University of Lund. It is primarily intended for substrate assays in which the reaction heat in a small column containing immobilized enzyme is measured as a temperature change of the effluent of the column. Temperature is measured with highly sensitive thermistors, and the temperature change is linear versus substrate concentration over wide ranges from 1 µM to several hundred mM depending, as reported by Danielson, on the actual enzyme reaction. Up to 60 samples per hour can be analyzed. Danielson and his group have studied a large number of metabolite assays of clinical as well as biotechnological interest. The ET assay can easily be automated as, for example, in the routine determination of penicillin by a computerized method that, according to Danielson, competes very favorably with high-pressure liquid chromatography (HPLC). The ET is well suited for monitoring and control of biotechnological processes due to its high operational stability. For monitoring molecules larger than enzyme substrates, an enzyme immunoassay (ELISA) has been developed and automated.

Hydrogen- and ammonia-sensitive semiconductors of Pd-MOS type combine

with enzymes and cells into highly sensitive biosensors. Danielson said that the hydrogen sensor which was developed at the Institute of Applied Physics at the University of Linköping, Sweden, is also useful for direct monitoring of biological processes that produce hydrogen. Addition of another layer of a catalytic metal such as iridium on the MOS device results in enhanced NH_3 or a rise in sensitivity. Highly sensitive methods for determination of, for example, urea and creatinine by production of NH_3 have been developed by Danielson and his group. A common feature of these gas sensors is that detection is made in the gas phase, while the reaction is carried out in aqueous phase to liberate NH_3, which facilitates work with crude samples.

The sensitivity of biosensors may be increased by substrate or coenzyme recycling as Danielson and his group demonstrated with a lactate/pyruvate recycling system employing lactate dehydrogenase, lactate oxidase, and catalase coimmobilized in an ET. A 1000-fold increase in sensitivity was obtained and substrate concentrations as low as 10 nM could be detected. Danielson and his group are presently studying other systems.

Gaseous-Media Biosensors

Biosensors previously described in the literature are useful only for assays in aqueous solution. For measurements of toxic compounds in the gas phase, a sample must be collected into the gaseous phase and then analyzed. A new biosensor approach, the use of protein coatings directly on an oscillating quartz piezoelectric crystal for the direct detection of pollutants in air was discussed by G.G. Guilbault (Department of Chemistry, University of New Orleans, Louisiana).

The piezoelectric crystal is based on the principle that the frequency of vibration of an oscillating quartz crystal is decreased by the deposition of a small mass on the electrode's surface. By putting a highly selective coating on the crystal, a response indicates the presence of the molecule for which the coating is selective. Quantitatively, the gaseous pollutants are adsorbed or partitioned by the coating of the electrode, thereby increasing the mass on the crystal and decreasing its frequency, according to the Sauerbrey equation:

$$\Delta F = -2.24 \times 10^6 \frac{F_o^2}{A} \Delta MS,$$

where ΔF = the change in frequency of the crystal; F_o = the basic frequency of the crystal; A = area of the electrode; and Δ MS = mass deposited by the adsorption or partitioning. The magnitude of the mass change, Δ MS, is linearly related to the concentration of substance present in the atmosphere.

Preliminary studies by Guilbault and his group have shown that biological substrates, such as enzymes and antibodies, have proven successful as coatings for a piezoelectric crystal detector. Immobilization of cholinesterase and parathion antibodies allows for the detection of organophosphorus pesticides at the level of parts per billion (ppb)--the cholinesterase coatings exhibiting a general response to all organophosphorus pesticides and the antibody coatings exhibiting a more specific response to parathion. Guilbault and his group observed excellent reproducibilities, coating lifetimes, response times, and selectivities. According to these investigators, this research is the first use of proteins as coatings for the direct assay of gaseous compounds, thus making this method an attractive alternative to some conventional techniques currently in use.

Guilbault and his group have applied the above technology to biosensors for contraband drugs (cocaine, morphine, heroin, etc.), for explosives in airport and post office surveillance. According to these investigators, the "nose" possessed by the biosensors they have developed using a protein layer on a piezoelectric crystal is more highly refined than the highly sensitive nose of a dog trained for scenting. Already their use in drug smuggling checks and for detecting hidden explosives is being considered by the US government.

Trends in Biosensor Technology

The realization that analysis and monitoring requirements could be revolutionized by biologically coupled sensor technologies has resulted in an acceleration of activity in biosensor development. Finding their major challenge to be the identification of a physicochemical event that can ultimately be transduced to an electrical signal, the workers in biosensor concepts have evolved developments most successfully, perhaps, around electrochemical and optical devices. One of the important problems with respect to biosensors is that the biologically active layer lacks stability. On account of their macromolecular structure, the constituents of this layer react with great sensitivity to external influences and thus reproducible measurements are difficult to achieve. Some of the initial successes that are in sight for biosensor technology were addressed by E. Hall (Biotechnology Center, Cambridge University, UK).

One of the simplest solid-phase biosensor constructions has been developed via an indicator dye around existing colorimetric determinations. Ideally suited to fiber optic technology, and using low-cost light-emitting-diode (LED) light sources and silicon photodiode detectors, these systems have a very low power consumption and allow the benefits of battery-operated instrumentation to be exploited, according to Hall.

Indicator labels can also be employed in immunoassay techniques, but the real goal here is the direct detection of antibody-antigen binding. To this end, evanescent wave and surface plasmon resonance systems are being exploited to investigate the immunoreaction by optical means, while, in parallel, the feasibility of electrochemical immunosensors is being explored. In all biosensors, immobilization of the biomolecule at the probe surface is crucial, and not least in the creation of amperometric biosensors. These electrochemical biosensors are primarily being developed for analytes that are substrates for redox enzymes. They monitor the electron transfer to the enzyme via an electrochemically active redox mediator. A new immobilization procedure focusing on the use of electrochemically grown redox polymers has been applied in the development of these biosensors where enzyme and mediator are irreversibly immobilized by the polymer matrix. One of the polymers used by E. Hall and her group is the conducting polymer, polypyrrole. Initial results from polypyrrole film amperometric electrodes realize the concept of a reagentless biosensor, and present an immobilization procedure that is attractive in its ease of preparation and reproducibility. Hall and her group are continuing their work in this area to perfect their biosensor system.

Biosensor Systems for Food Analysis

The determination of organic compounds in foodstuffs is very important for the control of food manufacturing processes. As various compounds are contained in foods, selective determination methods for these compounds are required in food industries. Most analyses of organic compounds can be performed by spectrometric methods based on specific enzyme reactions. However, these methods require long reaction times and complicated procedures. Therefore, electrochemical monitoring devices--biosensors employing immobilized biocatalysts--have definite advantages. The use of biosensors to detect widely different constituents of foods was discussed by I. Karube (Laboratory of Resources Utilization, Tokyo Institute of Technology, Japan).

Various sensors using immobilized enzymes and microorganisms have been developed for food process analysis. The determination of food freshness is important in the food industries. Since (in the meat putrefaction process) various kinds of amines are produced, their monitoring can be used as an indicator of meat freshness, according to Karube. An enzyme sensor consisting of a monoamine oxidase membrane and an oxygen electrode was developed by Karube and his group for the determination of monoamines, and may be used for the determination of monoamines in meat pastes. A linear relationship was obtained between the changes in current due to oxygen consumption and the concentrations of histamine, triamine, and 2-methylpropylamine below 1 mM. The determination of amines in meat samples was carried out on pork meat. The concentration of amines in meat paste increased with increasing incubation at 20°C. Therefore, it was possible to estimate the meat freshness with monoamine concentration.

Estimation of fish meat freshness is very important for the food industries for the manufacture of high quality products. After the death of fish, the decomposition of ATP in the fish meat sets in and ADP, AMP, inosine-5'-monophosphate, inosine, and hypoxanthine are subsequently generated. A new index of fish freshness is defined by Karube as:

$$K_1 = [(H_xR)+(H_x)]/(IMP)+(H_xR)+(H_x)]\times 100$$

where (IMP), (H_xR), and (H_x) are the concentrations of inosine 5'-phosphate, inosine, and hypoxanthine, respectively. In order to determine these compounds, an enzyme sensor system was developed by combining a double membrane consisting of a 5'-nucleotidase membrane and a nucleoside phosphorylase-xanthine oxidase membrane with an oxygen electrode. A small anion-exchange resin column was also connected with the enzyme sensor for separation of nucleotides. Each nucleotide concentration was determined as a current decrease. Furthermore, K_1 values were calculated by a microcomputer, and the freshness patterns were also displayed on a TV monitor. One assay was completed within 20 minutes. No appreciable decrease of current output was observed during 30 assays according to Karube. When a sample solution containing 10 mM IMP was applied, the response was reproducible within 8 percent. Good comparative results were observed between the K_1 values determined by the sensor and by the conventional method.

Karube and his group have also developed various kinds of microbiosensors for the determination of foodstuff

components. Microbiosensors for glucose and glutamate were constructed using silicon fabrication technology. A micro-H_2O_2 sensor was prepared and applied to a microglucose sensor. Glucose oxidase was immobilized using glutaraldehyde onto an organic membrane prepared by vapor deposition of gamma aminopropyltriethoxysilane. The sensor can be used for glucose determination in the range of 0.1 to 10 mg/dl. A microoxygen sensor was also prepared and applied to a microglutamate sensor. A linear relationship was observed between the glutamate concentration (5 to 50 mM) and the current decrease. Karube believes that in the future these microbiosensors could be integrated onto a single microchip and be utilized as a multifunctional biosensor for food taste examination.

Development of DNA Probes for Clinical Diagnostics

The detection and identification of infectious agents, especially bacterial and fungal, is usually time consuming and expensive. The procedures usually involve selective media, staining and microscopic evaluation, serological tests, specific enzyme activities (e.g., coagulase, oxidase, catalase, etc.), fermentative properties, and other biochemical tests. A great deal of work has been dedicated to finding new rapid diagnostic procedures. Among the most promising of these approaches are the uses of DNA probes in nucleic acid hybridization assays in properly treated clinical samples. This topic was discussed by R.J. Erikson (Cooper Laboratory, Inc., Mountain View, California).

Nucleic acid hybridization has been an important tool in the research laboratory for over two decades. The Watson-Crick structure of the DNA molecule predicted that the double helix could be easily separated (i.e., by heat or low pH) and, under the proper conditions, reannealed. This reassociation or hybridization would be dependent not upon the total composition (percentages of the four bases) of the DNA, but dependent upon the sequence of the bases. Thus, although *E. coli* and *N. meningitis* both contain approximately 51 percent GC (Guanosine-Cytosine) in their DNA, the DNA molecules of these two microorganisms do not cross-hybridize when mixed together. For this reason, DNA hybridization was used in the early 1960's to study taxonomic relatedness of bacteria by examining DNA homologies measured as the extent of cross-hybridization.

Major advances in the basic technology of nucleic acid hybridization were made by Gillespie and Spiegelman in their studies on the role of ribonucleic acid (RNA) synthesis during bacteriophage infection. In this work, the phage DNA was immobilized on a membrane matrix, and RNA--isotopically labeled *in vivo*--was used to differentiate phage RNA synthesis from total cellular RNA synthesis. This immobilization procedure and incipient "probe" concept initiated an enormous amount of work on the molecular basis of the regulation of gene expression.

The advent of recombinant DNA technology and genetic engineering in general has added a new dimension to nucleic acid hybridization techniques. The ability to isolate specific and well-defined DNA sequences, to incorporate them into a replicating unit in *E. coli*, and to be able to produce large quantities of these segments in pure form has proved an enormous benefit to basic studies in gene structure and function. It has also led to the development of DNA probes as diagnostic agents. The basic concept is quite simple. A DNA sequence that is specific for a given pathogen is isolated. This DNA is then derivatized with a reporter group that will allow its subsequent detection and quantitation. A clinical sample is then treated in a way that will liberate the DNA in any microbes or viruses present and, in most cases, immobilize the nucleic acid in a single-stranded form on an inert support. The probe is then added to this matrix and the hybridization reaction is allowed to occur. Obviously, if the given pathogen was present in the sample, the probe will hybridize to the DNA bound to the matrix. After sufficient washings to remove the nonhybridized probe, solutions are then added that will permit the detection of the reporter group of the probe. In theory, the DNA probe format is similar to the conventional antibody-based diagnostic test except that it functions at the nucleic acid rather than the protein level. An important point addressed by Erikson was that radioactive probes as used in research laboratories cannot be used in clinical labs. Therefore, the probes must be labeled nonisotopically with, for example, biotin. Erikson stated that his company, as well as many others, is developing DNA probes for clinical diagnostic tests. In some genetic diseases for which the gene has been isolated, a specific DNA probe is available for clinical diagnosis (hemophilia, thalassemias, phenylketonuria, etc.).

Biosorbent Materials for Metal Recovery

The development of metal-searching microbial biomass opens up a new area in biotechnology with many potential applications. Biosorbents can detect and absorb metals even at very low concentrations, as reported by B. Volesky

(Department of Chemical Engineering, McGill University, Montreal, Canada).

Biosorption is a property of certain types of inactivated (dead) microbial biomass that uptake, sequester, and concentrate heavy metals, nuclear fuel elements, and radionuclides from dilute solutions. The sorbed ions from the solution become deposited within the biomass particles and then the metal-laden biomass material can be washed, releasing the metallic species in a small amount of the wash solution which would contain the metal in high concentrations. The metal uptake, similar to that exhibited by ion exchange resins, is reversible, and, according to Volesky, the biosorbent can be regenerated for a multiple sequential reuse. However, it is anticipated that the biosorbents can be produced so cheaply that instead of washing and regeneration they could simply be combusted when laden with metal and desirable elements can be recovered in a highly concentrated form from the ashes. Some biosorbent materials are based on biomass which is a waste by-product of industrial fermentation processes.

As a result of recent work, several microbial biomass types have been identified which exhibit an extremely high biosorbent potential. US and Canadian patents have been isssued for the use of a very effective common mold of genus *Rhizopus* in biosorbent extraction of uranium and thorium. As reported by Volesky, these biosorbents have a four times higher uptake capacity for uranium and thorium than commercial ion exchange resins currently used in uranium ore extraction processes. Other metals such as chromium, nickel, cobalt, copper and zinc can be removed from solution and concentrated through the use of biosorbents. In one of the most recent discoveries by Volesky and his group, algal biosorbents have been extremely successful in the concentration of gold and platinum as well as several other strategic materials.

Volesky said that the potential use of biosorbents is anticipated in at least four applications:

- Extraction and metal concentration from ore-processing solutions
- Decontamination of mining wastewaters
- Extraction of valuable and/or strategic elements from seawater
- Decontamination of nuclear reactor waste solutions.

For practical applications of biosorbent materials the metal uptake phenomenon needs to be well understood if it is to be made highly selective for the desired metal ions. The selectivity of biosorption metal concentration processes can be effected on both sides of the process cycle--i.e., during the uptake and during the elution part of the operation. While studying the uptake behavior of the biosorbent system, valuable information can be obtained on the type of metal binding on the biosorbent. This information is supplemented by instrumental analyses such as x-ray diffraction, electron microscopy, etc. In general, according to Volesky, strong evidence has been developed pointing at the cell wall structural components being responsible for sequestering of metal ions. In the case of algal biosorbents, the porosity and reduction potential of some algal cell walls contributes a great deal to the deposition of relatively inert precious materials.

Study of the biosorbent behavior is an interdisciplinary and therefore difficult undertaking requiring specialized input from areas of chemistry, biochemistry, crystallography, and microbiology which has to go hand in hand with biosorption product/process development that itself, is based heavily on engineering input. Volesky stated that high sorption and desorption efficiencies are the key technological parameters for a successful metal extractive process based on biosorption. In addition, the physical properties of the biosorbent mass have to be modified to the extent that the mass can be conveniently used in a process sorption column or another type of contacting device. Volesky thinks that the development of biosorptive materials and extractive processes based on these materials represents an opening of a new area in biotechnology with an extremely high process application potential in the near future.

Conclusion

It is evident from the presentations at this conference that biosensors have emerged as a marketable product. Their high selectivity and sensitivity make biosensors an important and useful new detection system with numerous applications not only in human healthcare and veterinary fields but also in their use for process control and data analysis. There is still much work to be done in miniaturization and computer compatability. However, the progress that has been made in the development of the present generation of biosensors is an indication that further improvements will be made and new types of biosensors will be available in the near future.

5/20/37

Computer Sciences

THE BIRTH AND GROWTH OF CLIP--THE CELLULAR LOGIC IMAGE PROCESSOR

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

Introduction

The Cellular Logic Image Processor (CLIP) developed at University College, London under the direction of Professor Michael Duff and Dr. Terry Fountain had its origin in the late 1950's, when electronic computing was still in its infancy. The developmental work over nearly three decades has led to CLIP4, a 96×96 single bit processor array which operates in a single instruction multiple data (SIMD) mode, usually on images derived from the central one-ninth of a standard, noninterlaced television frame. It uses the central third of the middle 96 lines of each frame.

The development arose from the need to process data from high-energy particle physics which appeared as particle tracks in nuclear emulsions and cloud, bubble, and spark chamber photographs. At University College a small group called the Automatic Methods Group, in collaboration with the Nuclear Emulsion Group, developed a range of devices that could assist microscopists in finding and measuring the tracks of charged particles in their nuclear emulsions. The original semiautomatic system consisted of a microscope with one or more motorized movements and a digital position encoder on each movement. An observer had to set the microscope measuring graticule on the desired part of the particle track. The required calculations on the data were performed by solenoid-controlled mechanical adding machines or by arithmetic-logic circuits constructed from solenoid-operated relays. Gradually through the decade of the 1960's the relays were replaced by diodes and eventually transistors, and the human microscopists were replaced for some tasks by television cameras or scanned optical systems and photomultipliers.

A major problem with the system was the need for human operators to decide which data sectors to reject before recording, since it was not practical to record all the data in digital form. There was a need for a built-in pattern recognition capability in the scanning or recording system.

Researchers at University College were concerned with automatically locating areas of interest in charged particle tracks. A straight track was assumed to be not interacting so the problem was to locate sharp changes of direction in the track. These were called vertex points. A decision was made to build a parallel processing system, loosely modeled on the retina of the eye, to find vertex points automatically and rapidly, as a preprocessing stage prior to measurement.

Through the late 1960's and the decade of the 1970's a succession of such parallel processing systems were built, called CLIP1, CLIP2, CLIP3 and finally in the 1980's, CLIP4.

CLIP4

The CLIP4 system is an array of 9216 bit-serial processors, which can be configured as a square or hexagonal 96x96 array interfaced to two framestores holding six bit images. The input store is loaded from television camera optical workstations through an analog/digital converter which samples the central part of a noninterlaced standard television frame, producing the required digital image. The output memory off-loads through a digital/analog converter for display on a standard television monitor. Facilities are available for mixing, at variable intensities, the original analog image and one or more of the input or output digital images. Although CLIP4 can operate without a host computer, it is more convenient to use a conventional minicomputer for user communication, as it makes mass storage of digital images easier and makes possible use of high-level languages. A DEC PDP-11, operating under UNIX, is used as host processor. Although CLIP4 can only accommodate one user at a time, control can be switched to another user in a few seconds. The comprehensive file system provided by UNIX enables users to keep track of both their programs and their image data.

Workstations used to supply images to CLIP4 include:

- Illuminated Table. This employs both reflected and transmitted illumination. The TV camera, which can be raised or lowered, is equipped with a lens which gives a range of magnification of about 250:1, so that one pixel in the digitized image can represent anything between 25 μm and 6.25 mm in the object on the table
- Microscope. A conventional microscope with a micrometer driver X-Y stage, a rotating turret objective head, a TV

camera mounted above the microscope, and binocular eyepieces provides a means for direct digitization of images of microscopic sections. A prism is inserted in the optical path between the microscope and the camera so that images can be manually rotated prior to digitization.

- Optical bench. Two TV cameras are mounted on an optical bench that is equipped with lens holders and optical slits.
- Camera Trolley. One camera is mounted on a trolley and fitted with a motorized pan and tilt head and a power zoom and focus lens. This unit is used when large solid objects are to be imaged.
- Video recorder. A Sony U-MATIC video cassette is included to record or supply analog images as required.

The work stations are linked by a video distribution system. A user at any station can switch the camera output to a local monitor and is then independant of the rest of the system. Also, the processor image output from the CLIP4 console can be displayed. Users can carry out preliminary visual inspection of images before using the processor. Users communicate between the workstations and the host PDP-11 by means of a DEC VT100 visual display unit.

Mass storage of images is accommodated on two 5-MB and one 135-MB disks attached to the PDP-11. A small tape drive can be used in transporting image data to and from the laboratory.

Four methods have been tried for image hard-copy output: character overprinting using a Qume daisy wheel printer, dot-density methods based on a Versatec line printer-plotter, microfilm production using a microfilm plotter service, and direct photography of monitor screens using a polaroid film camera. None of the methods has proven entirely satisfactory.

Image Processing Software

The major features of the available software used with CLIP4 are:

- The UNIX operating system. The host computer (PDP-11/34) uses version 7 of the UNIX operating system. Its various facilities include file handlers, editors, compilers, and text formatters.
- CAP code. The assembly language for CLIP4 is called CAP. It is a mnemonic code assembling to 16- and 32-bit machine code instructions. The CAP subroutine library includes code from a range of image processing algorithms like image arithmetic, filters, convolutions, and histogram operations.
- Image-processing C. The high-level language C, which is used extensively in the UNIX operating system, has been extended to deal effectively with images. The image processing operations in the subroutine library are available as functions in C. The majority of the programs designed by the Image Processing Group are written in Image Processing C.
- The command system. The commands for image handling and inspection permit images to be written to or read from files, displayed numerically, and inspected using a keyboard-driven cursor. Image segments can be written out numerically using the Versatec printer.
- Menu. Most functions in the subroutine library are executed by two keystrokes on the visual display unit keyboard. The image displayed forms the input image, and the output image is then computed and appears in the display. Images can be named and stored temporarily in the array or on disk or permanently in disk files. MENU operations that are meaningful for both binary and grey images are called by the same instructions. The command *Eg* finds binary edges in binary images or grey edges in grey images. The command *V* counts 1-elements in binary images or integrates pixel volume in grey images.
- User Programs. Users of the system are encouraged to make their programs generally available as subroutines or as complete programs.

Applications

Although a later CLIP system, to be known as CLIP7, is being designed to handle large image areas in which processors and pixels are not one to one, applications for CLIP4 were chosen in which a 96×96 pixel image would represent a large enough image area. Three such projects are described in the following paragraphs.

Tomographic Reconstruction. This project used CLIP4 to reconstruct tomographic data from a radioactively labelled subject. Substances such as sugar can be tagged radioactively and injected into the subject's bloodstream. An Anger Camera, placed beside the subject, forms a two-dimensional (2-D) image of the radioactive material in the subject's veins. The camera is rotated around the subject into, typically, 72 different angular positions. The complete data set is 72 photographs of the patient, viewed from each of the 72 angular positions.

An image of a horizontal cross section of the subject is obtained by abstracting a horizontal strip from each of the 72 photos. In CLIP4, back-projection is used. It can be visualized as setting up 72 projectors in the appropriate angular positions and using parallel optics to project through the strip photographs across the central region originally occupied by the subject. The careful turning of suitable convolution functions applied to the strip images is the major factor in determining the resolution available in the reconstructed images. Since each 2-D image comprises a large number of horizontal strips, a large stack of horizontal cross sections can be computed, constituting a complete 3-D image.

In tomography a 64×64 pixel image is considered sufficient. The reconstruction time for a single cross section using CLIP4 and extrapolating to an optimized program using CLIP4 equipped with 2.5-MHz circuits is approximately 150 ms, which compares favorably with hard-wired special purpose computing circuits for reconstruction.

Electrophoresis Gel Analysis. This project was done in collaboration with the Imperial Cancer Research Fund Laboratories. Proteins can be made to spread out across thin gelatin sheets in two directions at right angles to each other and in the plane of the sheets. The displacement in one direction is proportional to the molecular weight of the protein molecule and, in the other, proportional to the molecule's isoelectric point. The displacements are caused by a complex diffusion process in a variable pH medium under the influence of an applied electrostatic field. The position of the proteins after diffusion can be made apparent by radioactive tagging or by staining. Ideally, each protein would be represented by a small, isolated dot, whose density would be proportional to the amount of protein present. In practice, every dot is blurred by being smeared in the two orthogonal directions, and adjacent spots touch or overlap.

The electorphoresis gel provides a form of map of the problems in the sample being investigated. Due to distortion with the smearing effect it is impossible to relate spot coordinate position directly to protein type. In the CLIP4 project an attempt was made to reverse the effects of smearing and gel distortion so that spot coordinates could be compared with those on a calibrated gel.

The smearing effect was assumed to be uniform in every region of the gel so that a deconvolution could be applied uniformly over the whole image, thus fully exploiting the array's parallelism. The gel distortion was removed by using known protein calibration points to compute a low-order distortion transformation, matching residual unmatched points by applying higher order corrections to bring nearby groups into correspondence.

Carotid Body Reconstruction. In collaboration with St. Bartholomew's Hospital Medical College, the Automatic Methods Group (now called the Image Processing Group) investigated the vasculature of the carotid body. This small pear-shaped organ, about 5 mm long in a rat, was sliced into some 250 μm sections that are then viewed under a medium-power optical microscope. The cross sections of the many small blood vessel forming the vasculature are clearly visible, but it is difficult to discern the structure of the complex network of vessels by examining consecutive slices.

In the CLIP4 project, the first task was to correctly align the slices one-by-one under the microscope, so that the images can be digitized in a correct relationship. The edges of the vessels are extracted, the centers of gravity are found for the edge images, and the second image is shifted so that the two centers coincide. The second image is then translated and rotated to minimize the difference between the two edge images. The exclusive OR function is used. The second microscope slide is moved so that it is aligned with its computed shifted image.

Various future-dependent tests are used to eliminate spurious edges, and then a stack of edge images is processed to trace through connected structures, taking further opportunities to eliminate edges that do not form part of connected structures. The system then puts out a graph-structural list that can be used to construct one of several alternative perspective views of the vasculature or of systematic representation of it.

Conclusion

CLIP4 is believed to be the fastest existing system for image processing. It has proven to be effective in practical applications, algorithm development, and other problems requiring highly parallel operations. It is currently used extensively at University College and will likely continue to be used for some years.

However, some image processing applications require higher resolution than that accommodated in CLIP4--i.e., 96×96 pixels. A resolution of 512×512, for example, is sometimes needed. It is not practical at present to construct systems with enough processors to allow one-to-one correspondence between pixels and processors for a 512×512 pixel image.

CLIP7, now in the planning stage at University College, will use a strategy of scanning a large pixel image by sections. This requires a system for exchange of signals between subareas of the image. A discussion of CLIP7 will be the subject of a future article in *European Science Notes*.

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5/23/87

Material Sciences

ELECTRONIC CERAMICS RESEARCH AT THREE ISRAELI UNIVERSITIES

by Robert Vest. Dr. Vest is the Liaison Scientist for Electronic Ceramics and Materials in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave from Purdue University, where he is Turner Professor of Engineering in the School of Materials Engineering and in the School of Electrical Engineering.

Introduction

Both the quantity and quality of scientific research in electronic ceramics being conducted at universities in Israel are very high, particularly when considered in light of the size and population of the country. In March of this year I visited the Hebrew University of Jerusalem, Technion-Israel Institute of Technology, and Tel Aviv University. In all three of these universities the scientists involved in research on electronic properties of metal oxides were in the physics departments, and the problems were addressed from a very fundamental point of view. However, in all cases the physicists were very aware of practical applications of the results, and guided the basic research in directions that would yield the information needed for these applications.

The Hebrew University of Jerusalem

In the Hebrew University's Racah Institute of Physics the group headed by Y. Yacoby and A. Agranat has been studying the fundamental nature of ferroelectric transformations in oxide perovskites for many years. Materials such as $KNbO_3$ were originally thought to be displacive ferroelectrics, but then it was suspected that some sort of disorder exists in all of the phases. Their earlier research using Raman spectroscopy (Yacoby, 1978) found that first-order Raman lines were observed for $KTaO_3$:Nb in the cubic (to x-rays) paraelectric phase, despite the selection rule which forbids first-order Raman scattering. They showed that the Nb ions were displaced in the [111] directions in the paraelectric phase and that the displacement was dynamical; the ions moved from one equivalent position to another in a time $\sim 10^{-11}$ seconds, which is short compared to laboratory time but long compared to Raman interaction times. In their current studies Yacoby and coworkers are using x-ray absorption fine structure (EXAFS) measurements to study the structures of $KTaO_3$:Nb and (NaK)TaO_3. The EXAFS studies to date show that the Nb ions are displaced 0.15 Å in the [111] direction in $KTa_{0.91}Nb_{0.09}O_3$ at 70 K where the structure is rhombohedral (Hanskepetitpierre, et al., 1986). Further, the displacement of the Nb ions does not change, at least up to room temperature, so that the ions are also displaced in the [111] directions in the ferroelectric phase. At the phase transition the average displacement of the Nb ion becomes non-zero together with a non-zero polarization of the host lattice. Therefore, this system is neither a pure displacive nor a pure order-disorder system.

Starting with the knowledge that the presence of impurities or defects strongly affects the ferroelectric phase transition temperature T_c in oxygen perovskites, Yocoby and coworkers proposed that a similar change in T_c could be created by the optical transfer of an electron from one type of impurity to another. Such a change in T_c would create a significant change in the dielectric constant K, and in the presence of an external electric field, these changes in K would create changes in the polarization, thus affecting the index of refraction. They are currently studying this dielectric-induced photorefractive effect in $KTa_{1-x}Nb_xO_3$ (KTN) doped with Ti and Fe.

The photorefractive effect serves as the basis for storing volume phase holograms, which is a very exciting area of information storage because the storage density can be as high as 10^{10} bits per cubic centimeter. The figure of merit of the photorefractive effect, which involves the bits stored, the bits read, and the required laser intensity, has been shown by Yacoby and coworkers to be

directly proportional to the change in T_c per absorbed photon for the dielectric-induced photorefractive effect. The figure of merit can thus be increased by approaching the phase transition (e.g., selecting the right composition in the $KTa_{1-x}Nb_xO_3$ solid solution) and by maximizing the change in T_c. They have shown that the figure of merit in Fe-doped KTN using the dielectric mechanism can be 100X better than with the field mechanism in the same material. Another advantage of the dielectric mechanism over the traditional field mechanism of the photorefractive effect lies in the fact that the crystal remains electrically neutral throughout the writing and reading of the holographic information. It is therefore expected that the reading of the information would not be accompanied by deterioration in the quality of the recorded information. Therefore, the dielectric mechanism, although weaker in KTN than the field mechanism, can be advantageously used for the implementation of holographic memory devices.

Technion-Israel Institute of Technology

The Technion in Haifa was the smallest of the three universities I visited in terms of number of students, but its academic programs are almost totally dedicated to the sciences and engineering. The Physics Department group headed by Dr. David Tannhauser and Dr. Jan Genossar is studying the structure and dynamics of vacancies in yttria-stabilized zirconia (YSZ), a material of technological importance both as a superionic conductor and as a structural ceramic material. Because the vacancies act as the charge carriers in YSZ and permit the motion of oxygen ions, the lattice geometry and the structural details of distortions in the neighborhood of the vacancies are important to determine. Experiments have shown that the ionic conductivity increases with increase in yittrium concentration and reaches a maximum at near 12-mole percent yittrium; the reason for this maximum is not clear. While it is clear that the vacancies reside in a mixed environment of Zr and Y cations, the constitution of the microscopic environment of vacancies (e.g., whether the vacancies are attracted toward Y or toward Zr ions) is not understood.

The current research by Tannhauser and Genossar involves electron spin resonance (ESR) measurements on quenched samples of YSZ which have been equilibrated with oxygen at a controlled partial pressure (H_2/H_2O atmosphere) at temperatures in the range 700-1000°C. Because of the partial reduction which occurs at the low oxygen pressure, part of the vacancies capture an electron and become singly ionized, and these vacancies give rise to an ESR signal. The observed magnitude of this signal changes with oxygen partial pressure according to $P_{O_2}^{-\frac{1}{4}}$. This dependence agrees with the prediction of a chemical equilibrium model for defects in YSZ as shown in the following two equations:

$$O_O^x \rightleftharpoons \tfrac{1}{2}O_2(g) + V_O^{\cdot\cdot} + 2e' \qquad (1)$$

$$V_O^{\cdot\cdot} + e' \rightleftharpoons V_O^{\cdot} \qquad (2)$$

where $V_O^{\cdot}$ denotes an oxygen vacancy with one trapped electron, $V_O^{\cdot\cdot}$ an oxygen vacancy with no trapped electron, O_O^x a normal oxygen ion on an oxygen site, and e' an electron. From these equations, and assuming that the concentration of oxygen vacancies is equal that of yittrium in the crystal, the group predicts that the concentration of $V_O^{\cdot}$ will be proportional to $P_{O_2}^{-\frac{1}{4}}$, as was observed experimentally. From the dependence of the concentration of the $V_O^{\cdot}$ on temperature, they calculated the ionization energy of the vacancy (equation 2) to be 0.78 eV. Further, they found that the g-tensor of the ESR signal had axial symmetry with [111] as the symmetry axis. From these results they have concluded that at room temperature every vacancy is bound to a Y ion as nearest neighbor. It is clear that such a simple model cannot hold at high temperature since it would prevent conduction by the vacancies. Consequently, the next phase of the research will be an extension of the ESR measurements to the temperature range 700-1000°C where the vacancies are mobile. The high-temperature sample holder has been built but Tannhauser and Genossar are still trying to secure a magnet with a 2-inch gap to accommodate the cell.

Tel Aviv University

The group headed at Tel Aviv by Dr. Dan Goldschmidt is studying oxides for photoelectrochemical decomposition of water. The titanates are of particular interest for this application, apparently because the titanium ion has the correct electron affinity for the process. The specific material under investigation is $Y_2Ti_2O_7$ doped with chromium (Cr). The Cr^{3+} ions substitute for the regular Ti^{4+} ion, creating an acceptor-like center which has to be compensated by a positive center in order to preserve charge neutrality. By reducing the band gap to approximately 3 eV, these acceptor centers sensitize the large band gap (3.8 eV) of yttrium titanate to solar radiation. The ability to incorporate large amounts of Cr in $Y_2Ti_2O_7$--in contrast to other titanates that become unstable and

undergo structural phase transitions--is the reason for interest in this particular oxide. Experimentally, they are measuring electrical conductivity, thermoelectric power, and the optical absorption edge as functions of temperature. Both the electrical conductivity and the thermoelectric power were found to be activated over the temperature range 100 to 600 K, but the activation energies were different. These results were interpreted as an activated mobility indicative of a small polaron scattering mechanism. From the combination of conductivity and thermal power Goldschmidt's group calculated a hopping energy of 0.13 eV and a hopping frequency of 3×10^{12} Hz, which are consistent with the adiabatic small polaron model. Their optical absorption studies showed that the optical band gap (E_g) shifts strongly with temperature (T) according to the relationship $\delta E_g/\delta T = -1$ meV/K. This value is much larger than that observed in similar oxides, and the large magnitude is believed to reflect the very strong electron-phonon interaction.

The single crystal samples of $Y_2Ti_2O_7$ were made n-type semiconducting by reduction in H_2 at high temperatures followed by quenching. Analysis of the transport results yielded a concentration of oxygen vacancies $>10^{20}$ cm^{-3} (i.e., ~1 percent). Their model invokes the high concentration of oxygen vacancies as the primary reason for both the mechanism of Cr uptake and the small polaron conduction. In the first case the vacancies act as compensators to Cr doping, while in the second they act to stabilize the small polarons. The large concentration of vacancies may also explain the strong temperature dependence of the band gap.

Summary

This report is only a brief selection of some research in electronic ceramics at three Israeli universities, and is by no means complete. There are many first-rate scientists in Israel who are addressing important problems in electronic ceramics. For example, I did not have the opportunity to visit Dr. Sidney Lang at Ben-Gurion University of the Negev who is doing some fascinating research utilizing the laser intensity modulation method to map nonuniform polarization distributions in poled ferroelectrics.

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5/22/87

RESEARCH ON ADVANCED CERAMICS AND GAS SENSORS AT HARWELL

by Robert Vest.

Introduction

Harwell laboratory is part of the UK Atomic Energy Authority and, with over 4,000 staff including 1,200 scientists and engineers, is the largest contract R&D laboratory in the UK. Harwell was founded in 1946 to provide the research and development needed by the UK nuclear power program but now covers a wide range of scientific disciplines in its 15 divisions. Today, 35 percent of Harwell's £125 million (about $210 million) annual income is derived from customers outside the nuclear field with the remainder coming from the UK Atomic Energy Authority. Approximately 20 percent of the total budget is marked for basic research, and the remaining 45 percent is dedicated to specific atomic energy projects for the government.

The Materials Development Division consists of approximately 350 people organized into 10 groups. I visited with Dr. Allan Atkinson from the Ceramic Technology Group, but the majority of the discussion during my visit concerned activities in the Sensors Group, headed by Dr. David E. Williams.

Ceramic Technology

Activities in this group are concerned with research and development of high-strength ceramics for engineering applications backed by design techniques, fabrication methods, and mechanical property assessments. The current activities are divided into two main areas: fabrication of ceramic powders by sol-gel processing and high-temperature performance predictions. An example of the latter activity is a recently completed study (Atkinson, 1987) of grain boundary diffusion in oxides and its contribution to oxidation processes. Experimental data for the preferential diffusion of species along grain boundaries in oxides, relevant to oxidation films, were reviewed and the likely atomistic processes responsible for diffusion were identified. The data were then used to access the contribution of grain boundary diffusion to oxidation processes such as film growth, the

distribution of impurities, and the influence of impurities on film growth in the oxidation of nickel-based systems (e.g., Ni, Ni-Y, Ni-CeO_2, Ni-Cr).

Semiconductor Gas Sensors

The Sensors Group at Harwell under the direction of Dr. Williams has been very active for a number of years, but most of their results have not as yet found their way into the open literature. This is because much of the work has been sponsored by customers outside the nuclear field and resulted in a series of patent applications (Williams, et al., 1985 a-d). They have developed excellent experimental facilities for evaluation of potential materials for semiconductor gas sensors and have conducted some excellent basic research, most of which they were willing to share with me. I will give a brief introduction to the theory of gas sensing by semiconductors so that the readers can achieve a better perspective on the current research at Harwell.

General. Two different classes of mechanisms of operation of semiconductor gas sensors can be distinguished. The first class involves changes in bulk conductance, whereas the second involves changes in surface conductance. The first class of materials relies on changes on bulk conductance, and generally is only sensitive to changes in oxygen partial pressure. In this case, the oxide defect chemistry is of central importance and the bulk of the material must be equilibrated with the ambient oxygen pressure. The second class of materials senses small concentrations of reactive gases in air which cause changes in surface conductance, and detect displacement from an equilibrium condition induced by the gas. In this second case, surface devices are also sensitive to changes in oxygen partial pressure, but the defect chemistry of the oxide is only of peripheral significance as far as the gas-sensing properties are concerned.

In the measurement of small concentrations of reactive gases in air, the gas phase is not at equilibrium and the components react on the surface of the sensor. Sensor indication therefore depends critically upon conditions of diffusion and reaction in the gas boundary layer near the sensor surface and within the porous sensor mass. In devices which utilize bulk conductivity changes, the sensor may be in equilibrium with the local oxygen partial pressure, but further catalyzed combustion by the sensor surface may again mean that the sensor indication may be influenced by conditions of diffusion and reaction of the gas phase within the porous sensor mass.

The selection of materials which satisfy the demanding criteria for a useful oxygen sensor element cannot be achieved by theoretical means alone because of the strong interrelationships between processes occurring in the solid semiconductor and in the gas phase. One of the major activities of Harwell's Sensors Group over the past several years has been to build a data base for a variety of materials. Their philosophy of experimentation was to devise a measurement routine which was simple to perform yet, although not necessarily measuring accurately, revealed the phenomena reliably. The prime variable is the composition of the material; using the simple experimental technique they developed, the experimenters are guided by chemical intuition and effectively make and test a wide range of compositions. The test system utilizes laboratory microcomputers to ramp temperature between predetermined limits, change the partial pressure of the species of interest in the gas phase, and then repeat the temperature programing while continuously recording electrical conductance data.

Bulk Devices. The change in stoichiometry of semiconducting oxides as a function of the oxygen activity in their environment at elevated temperatures is a well-known effect, and the electrical conductivity (σ) of such materials can be represented by the relation:

$$\sigma = \sigma_o P_{O_2}^{1/n} \exp [(E_1 + E_2)/kT] \qquad (1)$$

where k denotes Boltzmann's constant, T the Kelvin temperature, E_1 the energy required to form the appropriate defect in the oxide, E_2 the energy required for thermal activation of charge carriers, and the constant n depends upon the predominant point defects formed. For maximum sensitivity, n should be as small as possible.

The patent literature is filled with claims of sensors based on complex oxides using about every variable valence transition element. However, oxygen sensitivity alone is not sufficient because equation (1) implies that the sensitivity of conductance to temperature fluctuations could easily be much greater than the sensitivity to oxygen partial pressure changes. Therefore, sensors utilizing this phenomena either need an accurate temperature measurement and control system, which, in general, is expensive, or they must utilize a material of low enough activation energy. A low net activation energy might be obtained if the creation of the donor state was an exothermic process so that the two

energy changes (E_1, E_2) in equation (1) might cancel. A material whose composition is a strong function of temperature might satisfy this requirement, and the research at Harwell has shown that the substituted alkaline earth ferrates can be so interpreted.

The alkaline earth ferrates and ferrites ($CaFeO_{2.5}$, $SrFeO_{3-x}$, $BaFeO_{3-x}$) have highly defective lattices with ordered or partially ordered arrays of oxygen vacancies. The conductance of calcium ferrite is only slightly dependent on oxygen partial pressure, and has an activation energy of 0.2 to 0.5 eV, whereas the barium and strontium ferrates are much more conductive and have conductances that are strongly dependent on oxygen partial pressure; the P_{O_2} dependence is a strong function of temperature (n ∿5 at 800°C and ∿2 at 300°C), which is unusual for semiconducting oxides. The conductance activation energy (E) of the barium and strontium ferrates is dependent on both oxygen partial pressure and temperature; in air E varies from about -0.2 eV at 800°C through zero to about 0.2 eV at temperatures below 300°C. Over the temperature range 400-900°C in air, the composition of the barium and strontium ferrates $Sr(Ba)FeO_{3-x}$ varies, with x = 0.25 at lower temperatures and 0.5 at higher temperatures.

The properties of the alkaline earth ferrates can be altered by substitution of elements of valency four or five for iron, and of elements of valency three for the alkaline earth. In the series $BaFe_{1-y}Ta_yO_{3-x}$ ($0 \leq y \leq 0.5$) there is a continuous range of behavior from that of the near stoichiometric n-type semiconductor with y = 0.5 to that of the grossly nonstoichiometric p-type semiconductor with y = 0. Within this class, the Harwell group identified a range of compositions with y = 0.2 to 0.35 in which the activation energy is virtually zero over a wide temperature range, as shown in Figure 1.

The behavior of the barium tantalum ferrates was explained by the Harwell Group in the following way. The fully reduced material, which is n-type and has an activation energy of ∿0.5 eV, operates by reduction of Fe^{3+} to Fe^{2+} along with the formation of more oxygen vacancies. The oxidized material, which is p-type and has an activation energy ∿0.2 eV, operates by oxidation of Fe^{3+} to Fe^{4+} along with the insertion of additional oxygen into the vacancy arrays in the complex structure of the oxidized material. Since the composition is a function of temperature and the oxidized material has a higher conductivity than reduced material, there is a fortuitous cancellation of both effects on the conductance.

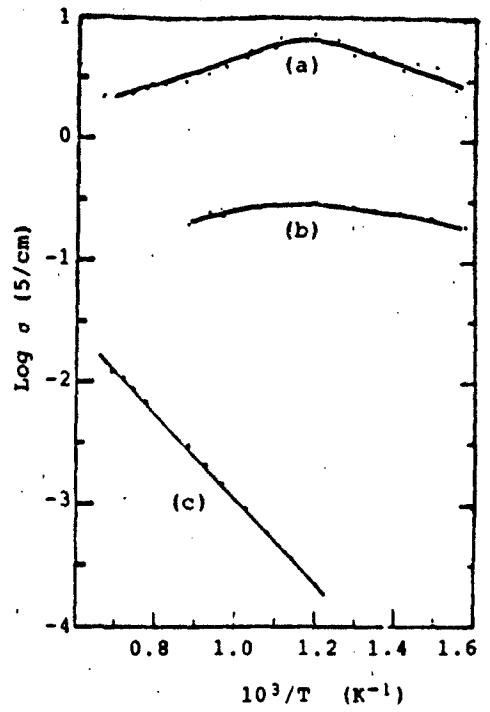

Figure 1. Comparison of the electrical conductivity of barium tantalum ferrates, $BaFe_{1-y}Ta_yO_{3-x}$: (a) y=o, (b) y=0.25, (c) y=0.5.

This leads to the occurrence of a maximum in conductance with temperature for $BaFeO_{3-x}$ (Figure 1a) and the smoothing out of the conductance (Figure 1b) as a consequence of the partial reduction caused by the tantalum substitution. The result is a class of materials which appear ideally suited for some applications requiring oxygen partial pressure measurement where it is not desirable or practical to incorporate temperature compensation of the devices. The Sensors Group has done some excellent basic research on these substituted ferrates, but very little has been published in the open literature because the sponsors of the program were much more interested in securing patent positions.

Surface Devices. There are a large number of ceramic oxide semiconductors that show a substantial conductivity change when only small concentrations of a combustible gas are present in a large excess of oxygen. Stannic oxide (SnO_2) is the material of choice for many sensing elements because it offers high sensitivity at a relatively low operating temperature. Much of the recent work at Harwell has addressed proprietary

additives to SnO_2, and some of the data they showed me on reponse of the sensors to step changes in gas composition were quite impressive. However, the people I talked with would not even give me a hint as to the deliberate additives used to enhance sensitivity, selectivity, and reproducibility. The basic research on tin oxide gas sensors at Harwell has been summarized in a recent publication (McAleer, et al., 1987); they would not discuss anything beyond what is contained in that publication.

Summary

The Sensors Group at Harwell is made up of some very competent scientists and engineers who have achieved a rare blend of fundamental and applied research to serve as a guide for sensor development. Much of the materials selection is still empirical, and they are generating one of the world's largest data bases concerning the response of the conductivity of semiconducting oxides to gas concentration and temperature. From this data base they will be able to refine theoretical interpretations, in addition to developing material compositions for optimum performance. They are demonstrating that basic research, applied research, and device development are not incompatible endeavors, and, in fact, that all three benefit from the interactions generated within the same group.

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5/22/87

Mechanics

AERODYNAMICS OF HYPERSONIC LIFTING VEHICLES--AN AGARD MEETING

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A meeting on the Aerodynamics of Hypersonic Lifting Vehicles sponsored by the Fluid Dynamics Panel (FDP) of the Advisory Group for Aerospace Research and Development (AGARD) of the North Atlantic Treaty Organization (NATO) was held from 6 through 9 April 1987 in Bristol, UK. The meeting attracted almost 200 participants from the NATO nations plus Switzerland and Australia. Participants from the UK, the US, France, and Germany accounted for the majority of the participants, and the majority of the presentations were from those countries, as might be expected from the intense activities taking place in these countries in support of recently announced programs to develop advanced aerospace orbiters.

The papers were divided into five sessions including: Facilities, Experimental Investigations and Techniques, Propulsion, Viscous Flows, and Vehicles and Design. The proceedings of this meeting are expected to be available from AGARD in August or September.

Hypersonic Testing Facilities

In the early 1970's, research and development activities in the field of hypersonics went into a period of decline from which they have only recently recovered as a result of new aerospace orbiter programs announced by the US (National Aero-Space Plane), the UK (HOTOL), France (HERMES), and Germany (Sänger).

The hypersonic flow domain extends from a Mach number of 4 to 30 and, in a typical vehicle reentry profile, both the continuum and free molecular flow regimes are encountered (see Figure 1). In addition, the effects of chemical nonequilibrium need to be considered (especially at high altitudes), and for aero-assisted orbital transfer vehicles (AOTV's) the effects of ionization need to be taken into account. This places great demands on the physical models used in computational simulation of the vehicle flow

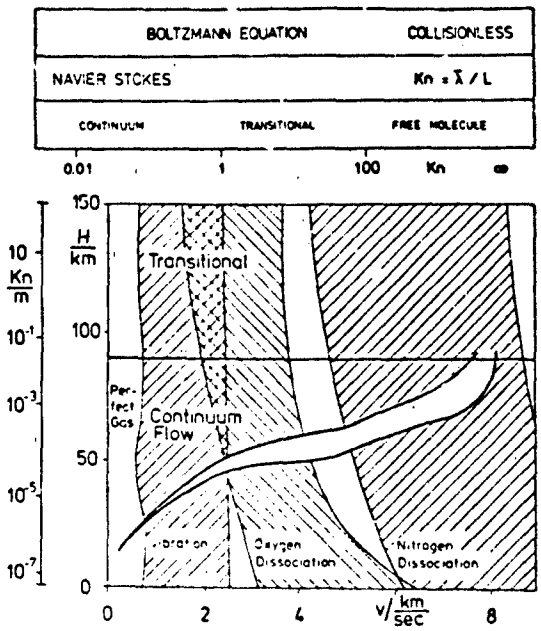

Figure 1. Hypersonic flow regimes with corresponding speeds, altitudes and Knudsen number ranges, including the flight envelope of a typical spacecraft.

field. Thus, although the hypersonic flow regime will probably be the first to be dominated by computational techniques, the next generation of lifting reentry vehicles will still rely on wind tunnel testing not only for design validation but also to verify computer codes through benchmark test cases.

It was, therefore, quite appropriate that the meeting opened with two review papers by C.E. Wittliff (Calspan Corp., US) and Dr. J.F. Wendt (von Karman Institute for Fluid Dynamics, Belgium) which surveyed hypersonic testing facilities in the US and Europe respectively. By means of a historical review of the capability of US hypersonic facilities, Wittliff illustrated the decline in interest in hypersonic research which occurred in the 1970's and early 1980's. After the design of the Space Shuttle and the design of various ballistic missile reentry vehicles and planetary probes in the early 1970's, many hypersonic experimental facilities were either moth-balled, placed on indefinite stand-by basis, or scrapped. Wittliff pointed out that in 1963 there were 82 facilities in the US representing a capability of testing in Reynolds number ranges from 10 million to nearly 40 million per foot, Mach numbers from 5 to 35, stagnation temperatures as high as 80,000°R, and stagnation pressures up to 100,000 psi. By 1985 only 19 such facilities existed with only one tunnel having high (greater than 25) Mach number capabilities, and only two having low (less than 50,000) Reynolds number capabilities, and only two facilities having stagnation temperature capability greater than 3800°R and flow velocities greater than 7,000 f/s.

Since 1985 the situation has improved somewhat with the construction of new facilities and the reactivation or renovation of old ones. Twenty-four hypersonic wind tunnels are presently in service; however, the many new programs presently under development including ground-based hypersonic intercepters, advanced ballistic research vehicles, and space-based AOTV's will place a heavy work load on the limited facilities which are available. In addition, the new National Aero-Space Plane (NASP) project has Reynolds number requirements which exceed by an order of magnitude the Reynolds number capabilities of the currently available facilities.

Wendt's survey showed that there are approximately the same number of hypersonic facilities available in Europe as in the US. The operating capabilities are similar in terms of Reynolds number per unit length and Mach number; however, the facilities are, in general, much smaller. As in the US, the European hypersonic tunnels are heavily committed. For the HERMES project alone, upwards of 2,000 occupancy days have been scheduled up to the year 1993. In addition, only two facilities (at Rheinisch-Westfälischen Technischen Hochschule, Aachen, and ONERA-Chalais Meudon) come even close to properly simulating the real gas effects (chemical reactions and dissociation) present in the HERMES and HOTOL flight regimes.

Wittliff and Wendt stressed the following needs:

- A large (greater than 2-m diameter) blowdown facility with Mach numbers from 8 to 10, reservoir pressures to 200 bar, and running times on the order of 10 seconds
- A high-velocity facility (velocities greater than 7 km/s) perhaps based on the "Stalker tube" concept
- A high-enthalpy, real-gas facility similar to the CF-4 tunnel at NASA Langley to simulate blunt body and high incidence effects
- Nonobtrusive measurement techniques to obtain flow field data such as density, temperature, and species concentrations
- Adequate numbers of trained personnel with experience in running facilities, selecting appropriate instrumentation,

and having familiarity with tunnel operation and data handling systems.

The remaining two presentations in the facilities session were devoted to descriptions by J.P. Chevallier of ONERA's new arc-heated intermittent hypersonic wind tunnel at Chalais Meudon and a description by R.J. Stalker (University of Queensland, Australia) of the new nonreflecting, high-enthalpy, piston-driven shock tunnel at the Australian National University in Canberra and a free-piston reflected shock tunnel at the University of Queensland for conducting hypersonic combustion studies.

Experimental Investigations and Techniques

Because of its nonobtrusive nature, laser Doppler anemometry (LDA) has numerous advantages over hot-wire anemometry in hypersonic flows and appears to offer the best means for obtaining much-needed information on the physics and structure of turbulence. As pointed out by F. K. Owen (Complere, Inc. Palo Alto, California), LDA specifically avoids the following problems faced by hot-wire anemometry techniques in high-speed flows:

- In hot-wire anemometry the term $\overline{(\rho u)'v'}$ is measured instead of $\overline{(\rho v)'u'}$, which is the desired component of the compressible shear stress.
- In hypersonic flows, local turbulence levels and the resulting directional intermittancy normally exceed that for which reliable hot-wire measurements can be expected.
- Obtaining the terms which appear directly in the momentum and energy equations from hot-wire measurements requires that the effect of pressure fluctuations is negligible. These effects are not small in hypersonic flows.

Because the seeding particles used in LDA measurements in hypersonic flows are required to be larger than those at low-velocity flows, Owen conducted an experimental investigation in the Air Force Wright Aeronautical Laboratories (AFWAL) Mach-6 high Reynolds number wind tunnel to determine the flow-tracking capability of such particles. Owen found that, after applying the Van Driest transformation to remove compressibility effects, the LDA measurements of the boundary layer on a flat plate agreed well with Cole's law-of-the-wall correlation. LDA measurements also showed good agreement with the law-of-the-wake correlation and the wake-like behavior in the outer region of the boundary layer when the LDA measurements were plotted in velocity-defect variables. In order to determine the response of the particles in a more demanding situation, the flat-plate flow was perturbed by introducing a 30-degree ramp. The results showed that the particle response was sufficient to produce the correct local flow angularity profiles across the boundary layer and to sense the presence of the ramp (by showing the retardation of the flow due to the imposed adverse pressure gradient.)

In addition, the LDA measurements of the streamwise turbulence fluctuations on the flat plate were compared with Klebanoff's incompressible results, and good agreement was found between the hypersonic LDA measurements and Klebanoff's incompressible hot-wire data. (Incidentally, this is in contrast with previous hot-wire hypersonic results which showed that the streamwise turbulence fluctuations in hypersonic flows were much less than those present in incompressible flows. It is possible that this discrepancy is due to the influence of neglecting pressure fluctuation effects when calculating hot-wire velocity fluctuations at high Mach numbers.)

For the ramp flow, Owen's LDA data showed that the streamwise turbulent kinetic energy was more than three times that for the flat plate boundary layer, and that the turbulent mixing length scales were an order of magnitude greater, which indicates large-scale unsteady flow ahead of the interaction region.

Owen concluded that the feasibility of LDA for making turbulence measurements in the AFWAL facility and adequate particle-tracking capabilities were demonstrated. He cautioned, however, that considerable work is still required to optimize seeding-particle requirements and to define the flow region in which reliable particle tracking can be expected in other hypersonic test facilities.

Several investigators looked at the shock/shock and shock/boundary-layer interactions produced at supersonic and hypersonic Mach numbers in a variety of geometries including intersecting wedge, fin, and circular cylinder geometries. The most complex geometry was considered by D. Hummel (Techniche Universität Braunschweig, West Germany), who looked at the flow field generated by a pair of intersecting wedges. He examined, in a careful parametric study, the influence of varying the corner and sweep-back angles in his institute's shock tunnel at Mach numbers between 12.3 and 16. Pitot and wall pressures as well as wall heat transfer were measured in the corner regions of intersecting wedges for different sweep and corner angles. In addition,

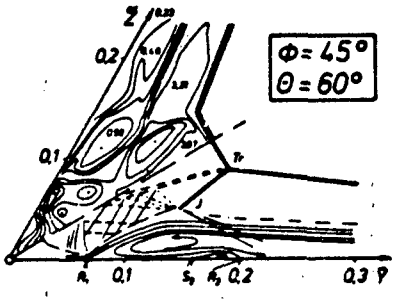

Figure 2. Pitot pressure isobars.

wall flow visualizations were made with an oil-dot technique. Figure 2 shows the Pitot pressure field measured by Hummel for a 60-degree corner with 45-degree sweep. The upper part of the flow field presents the isobar contours and the lower portion of the figure contains a qualitative interpretation of the flow field based on the measurements. Notice the high resolution of the measurements. Obviously, this data would be of great value in assessing the validity of numerical computations of such flows.

N.R. Fomison (Cranfield Institute of Technology, Cranfield, UK) looked at the glancing shock-wave/boundary-layer interaction produced by a single fin and examined the effect of leading edge sweep and bluntness. Again various sweep angles were investigated, and static pressure measurements were made in addition to flow visualizations.

Blunted fins were also examined by D.S. Dolling (University of Texas at Austin). In these tests, as well as in companion tests for the flow around circular cylinders of various heights and diameters, Dolling searched for the driving mechanism of unsteady separation at Mach numbers of 3 and 5. The main thrust of the work was to determine the frequency distribution of the shock wave motion using a conditional sampling technique. In the course of this study he discovered that single-threshold conditional sampling techniques used by previous authors (including himself) were unable to distinguish between pressure fluctuations induced by the shock and those produced by the turbulent pressure fluctuations in the boundary layer. By means of a double-threshold technique Dolling was able to avoid this problem. Dolling found that the cylinder and blunt fin flows exhibited the same general trends and that the maximum mean frequency could be correlated reasonably well by means of a Strouhal number based upon the free stream velocity and the diameter of the cylinder or the leading edge bluntness. In addition, he found that the frequency of shock motion was orders of magnitude less than the large-eddy time scales or the frequency of turbulent bursting. This led him to question the commonly held belief that the shock wave oscillations are driven by turbulence in the free stream flow. Instead he concluded that the shock motion is driven by the low-frequency unsteadiness in the region of separated vortical flow downstream of the obstacle.

In experiments conducted by T.J. Rhys-Jones (Royal Aircraft Establishment, Farnborough, UK) the drag coefficient of slender cones, biconics, and triconics was measured in the transitional rarefied flow regime--that is, between the regimes of continuum and free-molecular flow. In these experiments a parametric study was undertaken to examine the effects of various cone angles, cone bluntness, and Knudson numbers on the drag coefficient at Mach numbers of 8.6 and 9.4. Special attention was given to the mounting of the cones to avoid the sting and shroud interference effects which were believed to be responsible for the scatter shown in earlier data. The drag coefficient was found to increase with Knudsen number between the continuum and the free-molecular flow limits.

In some tests, the projectile is fired into the flow rather than being held stationary. In such situations, flow visualization requires intense, short-duration illumination in order to reveal the details of the flow around the projectile and particularly in the projectile wake. A means for making such photographs was described by A. Köneke (Institut Franco-Allemand de Recherches de Saint-Louis, France). He described an experiment in which high-resolution photographs of the projectile wake were made by illuminating the projectile wake with ultrashort, highly energetic pulses from an acousto-optical modulated laser. The advantages pointed out for using this set-up were:

- The parallax errors encountered when the multispark (Cranz-Schardin) method is used are eliminated
- The acousto-optical modulation technique avoids the synchronization problems present when a pulsed laser is used
- Use of a laser, instead of a spark source, produces a monochromatic image which can be easily filtered to remove unwanted background noise, and in addition, the use of the laser provides the capability for holographic imaging.

Propulsion

T.J. Waltrup (Applied Physics Laboratory, Laurel, Maryland) presented a thorough review of the development and current status of ramjet and scramjet engines. With regard to the design and development of scramjet engines in the Mach 3 to 7 speed range, he believes that the major pacing items are a need to understand turbulence at supersonic and hypersonic speeds; to predict the effect of turbulence on wall shear, heat transfer, and separation and reattachment; and to obtain a better understanding of the influence of turbulence on mixing and the interaction between turbulence and combustion.

Some encouraging evidence that the methods found to promote mixing in low supersonic speed combustors might be the same as those found to be effective in subsonic combustors was provided by K.C. Schadow (Naval Weapons Center, China Lake, California). In particular, he found that mixing could be enhanced if an elliptic rather than a circular jet were used, even at low supersonic (1 to 1.3) Mach numbers. Evidence for this was provided by schlieren photography and hot-wire measurements in both cold and reacting flows. The more rapid decline of the centerline velocity and the contraction of the jet isotherms both point to the enhanced mixing taking place in the elliptical jet. Unfortunately, linear stability analysis shows that the differential growth rate in phase velocity on the major and minor axes of the ellipse which is responsible for the enhanced mixing decreases sharply with increasing Mach number. This seems to suggest that methods of mixing enhancement found effective at low supersonic Mach numbers might lose their effectiveness at higher Mach numbers. Schadow's measurements of the decrease in centerline turbulence with increasing Mach number add to the predicament by suggesting that the mechanism by which mixing takes place (namely, the vertical turbulence fluctuations) might be substantially reduced in high Mach number supersonic flows.

Schadow appears to feel that, despite the predictions of linear stability analysis, the elliptical geometry will continue to show beneficial mixing characteristics due to effects not accounted for by the stability analysis such as the presence of nonsymetrical shock structure in the elliptic jet. Only when tests at higher Mach numbers are complete will we know for sure. All we can say at the moment is that experimental results have yet to show that mechanisms other than those found effective in enhancing subsonic mixing are required to enhance mixing in supersonic flows.

Computational Fluid Dynamics

Despite the difficulties of modeling the interaction between turbulence and chemistry, and the difficulties associated with the determination of transition, and problems associated with real gas effects, many successful computational fluid dynamics (CFD) simulations of hypersonic flow fields have been made. The most presentations concerned the calculation of viscous flow in the continuum regime by means of finite difference solutions of the Navier-Stokes equations. However, attention was also given to the solution of the Euler equations as well as to the influence of various wall treatments (surface temperature and wall catalysis) and different treatments of the chemistry (equilibrium vs. finite rate chemistry).

A. Kumar (NASA Langley, Hampton, VA) described his two- and three-dimensional Euler/Navier-Stokes simulations of the flow in supersonic combustion ramjet (scramjet) inlets. He used an algebraic coordinate transformation to generate body-fitted coordinates which were capable of accommodating embedded bodies such as struts and cowls. The transformed governing equations were solved by either the explicit or explicit/implicit MacCormack method. For the turbulent flow calculations, an algebraic two-layer eddy viscosity model due to Baldwin and Lomax was used. Excellent agreement with the measured sidewall static pressures was attained for an inlet operating at free-stream Mach numbers of 4 and 6.

Typical of the remainder of the papers in this session was that of Y. Rizk (Sterling Federal Systems Inc., Palo Alto, California), who described his viscous hypersonic calculations for the flow over the Shuttle orbiter. His three-dimensional calculations made use of a time-dependent, factored procedure to solve the thin-layer Navier-Stokes equations using streamwise or normal flux splitting procedures could be used. Similar to other calculations, the bow shock was fitted rather than captured in order to conserve on the number of points needed in the calculations. The shocks in the remainder of the flow field were captured. Excellent agreement with the windward side static pressure measurements on the Shuttle at Mach number of 8 and angle of attack of 25 degrees were produced. In this, and in a companion calculation of flow at a Mach number of 25 about a generic wing-body configuration at an angle of attack of 5 degrees, Rizk found that normal (in contrast to streamwise) flux splitting resulted in a sharper bow shock, but required more iterations because of the explicit treatment of the viscous terms. In the future

he intends to add real gas effects to these calculations.

An alternative approach is to use space-marching techniques rather than to seek steady solutions as the asymptotic limit of time-dependent calculations. Such space-marching schemes were described by H. Rieger (Dornier, Friedrichafen, West Germany), using a finite volume technique. He presented viscous and inviscid solutions of the parabolized Navier-Stokes and Euler equations. Excellent agreement was shown with the static pressure distribution on the surface of a hypersonic compression ramp at a Mach number of 14 and with the static pressure and heat transfer measurements on a 10-degree half-angle cone at incidences of 12 and 24 degrees at a Mach number of 8.

The papers by B. Aupoix, Office National d'Etudes et de Recherches Aérospatiales (ONERA), Toulouse, France, and M. Pfitzner, Messerschmitt-Bölkow-Blohm (MBB) Munich, West Germany, examined different aspects of real gas modeling and the effect of various wall treatments. Aupoix's calculations concerned the prediction of the heat transfer rate on the windward side of a hyperboloid of revolution at Mach numbers from 9 to 28, simulating the early reentry phase of the Space Shuttle. His interest was in the sensitivity of the heat transfer predictions to the reaction rates, wall catalysis, wall temperature, Schmidt and Prandtl numbers, and to the completeness of the chemistry model used to describe dissociation and oxidation reactions. The flow was modeled by means of first-order boundary layer equations which were solved by Patankar's finite-volume scheme using a pressure distribution provided by Newtonian theory. The results showed that the heat transfer rate was most sensitive to wall catalysis and reaction rates and least sensitive to the number of equations used in the chemistry modeling and to the values of the Schmidt and Prandtl numbers.

Pfitzner's calculations considered a Shuttle-like geometry but were concerned with the latter stages of reentry where high temperatures (between 4,000 and 16,000°R) produced the dissociation of oxygen and nitrogen and an excitation of their vibrational degrees of freedom which necessitated the use of both a generalized equation of state and the inclusion of temperature-dependent specific heats. He assumed the flow to be at chemical equilibrium and in the continuum flow regime. By means of a split-matrix algorithm he solved the time-dependent Euler equations to determine the surface pressure and static temperature on the Shuttle nose. Pfitzner's real gas model which made use of the equilibrium air properties of Tannehill and Mugge (1974) produced significantly different results than were obtained when the ideal gas assumption was applied. At a Mach number of 15 on a 15-degree half angle blunted cone at zero incidence, static pressures obtained within ideal gas and real gas models differed by as much as 25 percent and static temperatures by almost 6000°R.

The computations as described by H. Oertel, Deutsche Forschung und Versuchanstalt für Luft und Raumfahrt (DFVLR), Göttingen, West Germany, consisted of more or less conventional Navier-Stokes calculations for hypersonic flow over a complete Shuttle and a HERMES nose and a comparison of the results with observed pressures and heat transfer rates. The second and more interesting calculation was for the flow over a blunt body in the gas-kinetic flow regime. For these calculations he used the Boltzmann equation, which he solved with a direct-simulation, Monte-Carlo (DSMC) technique. Oertel found that the DSMC calculations were superior to those obtained with the competing Molecular Dynamics approach. No comparison with experimental data was shown. (In this connection, it occurred to me that the drag measurements made by Rhys-Jones reported earlier in this article might provide the data for such a comparision.)

The final paper in the session concerned the calculations of the flow over a wing/body combination by N. Qin (University of Glasgow, UK). It involved the use of an implicit finite difference method to solve the conical form of the Navier-Stokes equations. (See *ESN* 40-4: 201-202 [1987] for additional details.) Wall pressures agreed well with experimental measurements at all angles of attack. The accuracy of the heat transfer calculations appeared to deteriorate with increasing incidence; however, this might be due to a coding error. Finally, Qin showed a comparison between his viscous calculations and the results of an identical case in which the Euler equations were solved. The cross-flow velocity vectors of these two calculations are shown in Figure 3. The almost complete lack of correspondence between the Euler and Navier-Stokes calculations clearly demonstrates the dominant role which viscosity plays in establishing not only a quantitative but the qualitative nature of the flow in such situations.

Vehicles/Design

The remainder of the papers at this meeting concerned various aspects of wave rider design (from both an experimental and computational viewpoint) and reports

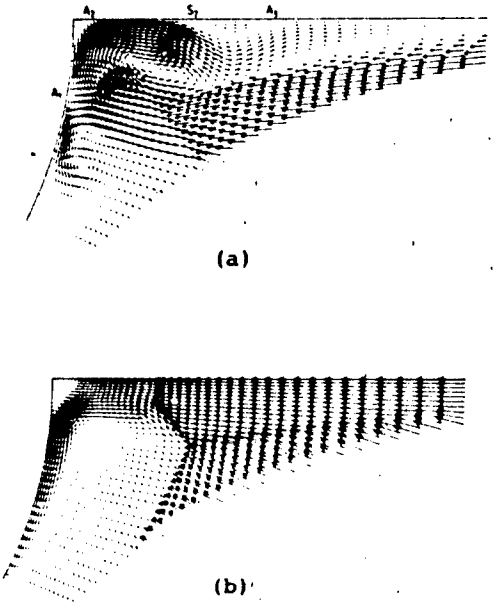

Figure 3. Cone-delta wing, M=12.65, 5° angle of attack: (a) Navier-Stokes calculation (b) inviscid calculations.

from the feasibility and design teams responsible for the new HOTOL and HERMES orbiters. Wave riders are vehicles which capture the bow shock along their leading edges. This results in significantly higher lift coefficients for given lift/drag ratio than is given by conventional designs.

A very complete experimental study of vortex formation over wave-riders and delta configurations at supersonic speeds was presented by J. Szodruch (MBB, Bremmen). With the use of oil-flow visualizations on the surface and vapor screen visualizations in the free stream, he constructed an extremely detailed classification of the separation patterns. (This work provides a valuable extension to similar vortex studies reported in *ESN* 41-1:20-24 [1987]).

The off-design performance of hypersonic wave riders was discussed by L.N. Long (Lockheed, Burbank, California). His paper reported a computational study in which the time-dependent Euler equations were solved by Jameson's Runge-Kutta scheme to produce such global error dynamics parameters as the (inviscid) lift/drag ratio, pitching moment, and surface static pressure distributions. By means of an extension of the code to solve the Reynolds-averaged Navier-Stokes equations, Long hopes to include the effects of aerothermal heating, skin friction, and displacement thickness.

These two papers were followed by several presentations in which approximate methods (Newtonian theory and integral boundary layer analysis, for example) were used in place of solutions of the Navier-Stokes and Euler equations to optimize wave rider shapes and to predict their dynamic stability. A particularly interesting study was presented by K.G. Bowcutt (University of Maryland, College Park) who described a viscous wave-rider optimization which made use of the nonlinear simplex optimization technique. All previous wave rider optimization work has been based on inviscid calculations to which skin friction corrections were subsequently added. Bowcutt discovered that including viscous effects as an integral part of the design procedure resulted in optimum aerodynamic performance which exceeded that predicted for previous studies and also resulted in distinctly different optimized shapes. He also found that the details of the viscous effects, such as how the shear stress is distributed over the surface and the location of transition, exercise a significant influence over the geometry of the optimized configurations.

The importance of viscous effects was also brought out in a paper by R.A. East (University of Southampton, UK) in which he compared various prediction methods for determining the hypersonic static and dynamic stability of various axisymetric shapes. He concluded that although the embedded Newtonian technique provided a suitable method for approximating the prediction of aerodynamic stiffness and damping, when effective structural change is present (brought about by transition and/or separation) viscous contributions to the stability derivatives cannot be ignored.

Hypersonic dynamic stability was also discussed by W.H. Hui (University of Waterloo, Canada). His predictions of the small-amplitude pitching motion about steady flight at a trim condition also showed that Newtonian theory (actually unsteady Newton-Busemann theory) provided sufficiently accurate results.

A.J. Wake (British Aerospace plc, Preston, UK) described the results which have been obtained to date on a proof-of-concept study involving the UK's HOTOL program, which was begun in 1985. HOTOL is a joint British Aerospace/Rolls-Royce program to design a totally reusable airframe with a hybrid, unmanned, air-breathing propulsion system aimed at placing payloads into low earth orbit for 20 percent of the cost of the US Space Shuttle, (*AAS* 49-86 [1986]). After comparing the HOTOL and Shuttle reentry

trajectories and introducing what she called the "infernal triangle" (representing the interaction of trim/control, cross-range, and heating rate) she identified three high-risk areas in which collaborative European research activity was needed. These included:

- Accurate estimates of temperature and heating rates
- Prediction of the position and magnitude of local hot-spots caused by shock interactions
- Prediction of accurate forces and and moments during reentry.

Progress in the design of the French orbiter, HERMES, was described by P. Perrier, Head of the Aerodynamics Department at Avions Marcel Dassault-Breguet Aviation (Saint Cloud, France). HERMES is approximately one-half the size of the Shuttle (*MASB* 50-86 [1986]) which introduces increased heat transfer and aerodynamic stability problems. To date, more than 150 design variations have been examined. The flight of the first of two technology demonstrators is scheduled for 1989 with the first HERMES flight scheduled for early 1992.

Final Observations and Conclusions

The presentations demonstrated the high level of activity present in the field of hypersonics today. Examples of experiments and computations representing the entire reentry profile were presented. A need was clearly demonstrated for improved techniques for predicting real gas effects and for experimental facilities to guide and demonstrate the validity of such calculations. In particular, high enthalpy facilities are needed to study real gas effects, and for AOTV-type vehicles high Mach number, low-density facilities are needed to better address the high Knudsen number, high-velocity regime. As remarked by one of the participants, there is clearly no shortage of problems on either side of the Atlantic which will require solution if the 1990's launch dates for the European and second-generation American aerospace vehicles are to be met.

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4/27/87

EUROMECH 220: MIXING AND CHEMICAL REACTIONS IN TURBULENT FLOWS

by Eugene F. Brown.

Introduction

EUROMECH 220: Mixing and Chemical Reactions in Turbulent Flows, was held at Girton College, Cambridge, UK, from 18 through 20 March 1987. The purpose of the colloquium was to bring together mathematicians, meteorologists, chemical engineers, air pollution scientists, and combustion specialists to discuss recent research into basic aspects of mixing and chemical reactions in turbulent flows. Approximate 50 scientists were in attendance with 60 percent of the participants coming from England, 20 percent from France, and the remainder from the Netherlands, Greece, Germany, Spain, Portugal, and Switzerland. Twenty-six papers were given, representing an appropriate balance between computational, theoretical, and experimental investigations. The informality of the meeting encouraged the sharing of both successes and failures and provided a forum in which the results of work in progress could be presented. As with all Euromech meetings no formal proceedings will be published, although a summary of the presentations will be prepared for publication in the *Journal of Fluid Mechanics* by the organizers, Dr. J. Hunt and Professor K.N.C. Bray, both of the University of Cambridge, UK.

Turbulence from the Lagrangian Point of View

Dr. Hunt presented his work on turbulence from a Lagrangian point of view. In this work, which was a combined theoretical and experimental study, attention was focused on the calculation and the measurement of the trajectory of particle pairs in isotopic homogenous turbulent flows. Of particular interest were such quantities as the cross-correlation coefficient, the segregation parameter, and the particle-separation probability density function.

Of tremendous assistance in such studies has been the development of new diagnostic tools such as coherent anti-Stokes Raman spectroscopy (CARS). Although this is the most widely used laser-based diagnostic tool in use today for the investigation of combustion problems, CARS has its limitations--its lack of sensitivity (accurate measurements are not possible at concentration levels less than 2 percent), low sampling rate (nominally 10 Hz), relatively large probe volume (as large as 14 mm long), and complex data analysis (sometimes requiring

upwards of half an hour of supercomputer time). Dr. D. Greenhalgh described two alternatives to CARS--degenerate four-wave mixing (DFWM) and picosecond absorption modulation spectroscopy (PAMS). These two techniques, unlike CARS, use only a single laser source, and, in addition, offer simple data analysis, no requirement for external calibration, excellent signal-to-noise ratio, a smaller probe volume (10 percent of that of the CARS system), and a sensitivity approaching one part per trillion.

Like Hunt, the presentation by Professor J. Eaton (Stanford University, California) considered the subject of the Lagrangian view of turbulence. He described three current projects in which he was involved both a Stanford and at Imperial College, UK, in which physical and numerical experiments to determine particle dispersion in turbulent flows were being carried out. Of particular interest to Eaton was obtaining an improved understanding of particle-laden turbulent flows and providing a sounder basis for the practical modeling of such flows. In these studies particular attention was given to understanding the relationship between the Lagrangian statistics of turbulent motion and the better-understood Eulerian statistics and the manner in which the turbulent motion is influenced by the presence of particles. On this latter point Eaton proposed that, unlike the turbulence damping built into some turbulence models for two-phase flows, the presence of fluid particles might well *increase* the turbulence levels by introducing new instability modes. The numerical experiments are being carried out with the full simulation code developed by R. Rogallo of NASA-Ames which has been modified to include the tracking of particles. The particles are treated as noninteracting spheres which follow an empirically-modified Stokes drag law. At present, only isotropic turbulence has been examined but an extension to nonisotropic flows is straightforward and will be completed soon. Preliminary results indicate that there is no difference between Eulerian and Lagrangian statistics. This was an unexpected result for which an explanation is currently being sought.

Future experimental studies will feature measurements of particle dispersion in a two-phase jet and in a vertically oriented diffuser. In both cases, the fluid phase is air and the particles are solid spheres of approximately 15 micron diameter. The study of jets will focus on the influence of the solid particles on the large-scale coherent structure of the jet and prospects for the control of turbulent structure by means of solid particle injection. Laser-based flow diagnostics will include laser-sheet flow visualization (by means of a 20-W copper-vapor, pulsed laser), particle tracking anemometry, and conventional laser Doppler anemometry (LDA) in which independent measurements of both the gas and particle velocities will be made. In the diffuser tests, the effect of particles on the turbulent sidewall boundary layer will be examined including their influence on the energy distribution, shear stress, wall friction, and boundary layer growth. As in the jet study, attention will be focused on the effects of the particle motion on the turbulent structure and on the role which vorticity plays in producing local inhomogeneities in the particle concentrations.

Calculation of Mixing and Combustion

By far the most innovative calculations of mixing and combustion were described by Dr. G. Searby of the Combustion Research Laboratory of the University of Marseilles (St. Jerome), France. In his presentation he showed simulations of counterflow mixing and a turbulent premixed planar flame calculation which exhibited the well-known cellular flamelets produced by the Darrieus-Landau hydrodynamic instability. The calculations were carried out by means of the lattice-gas model developed in 1972 by Pomeau (Hardy and Pomeau, 1972). In the lattice-gas model, the behavior of large assemblies of molecules are simulated by the motion of discrete fluid particles governed by simple collision rules and the observance of the conservation laws of mass, momentum, and energy. Under these conditions it can be shown that when viewed from a macroscopic perspective, the motion in this microscopic world obeys (or nearly so) the conventional continuum forms of the conservation of mass and the Navier-Stokes equations. Although inspired by the calculation of molecular dynamics in the field of theoretical physics, the application of such methods to the calculation of fluid dynamics problems is quite new, the first results having been obtained less than 2 years ago (*ESN* 40-8:266-269 [1986]). Although at first glance it looks as though this technique has something in common with the well-known Monte-Carlo or random walk simulations, the resemblance is only superficial since the trajectory of the fluid particles is governed by completely deterministic collision rules rather than by stochastic processes.

In the work described by Searby, the basic method has been extended by the addition of labels to the fluid particles. This makes it possible to distinguish between the particles on either

side of an interface and to simulate chemical reactions. For the simulation of combustion, the particle labels are allowed to change during the course of time by modifying the collision laws to allow (at least) for different kinetic energies of the burned and unburned particles. Although simulations with Mach numbers as high as 0.65 and Reynolds numbers well over 1,000 have been run, lattice-gas calculations are in principle restricted to low Mach numbers (in order to produce macroscopic similarity to the Navier-Stokes equations) and to low Reynolds numbers (in order to limit the computational time). This is because similarity with the Navier-Stokes equation requires that terms depending on the square of the Mach number be negligibly small and because the computational time increases as the Reynolds number cubed. For low Mach number, low Reynolds number flows, lattice-gas calculations are computationally competitive with solutions of the Navier Stokes equations and their simplicity and massively parallel logic make them ideally suited to special-purpose, high-speed parallel computers (of the "hypercube" variety).

Experimental Work in Turbulence Structure

An example of the experimental work presented at the meeting was the study of the turbulence structure of mixed flames presented by Dr. M. Heitor of the Instituto Superior Tecnico (Lisbon, Portual). This work, done in conjunction with Professor J.H. Whitelaw at Imperial College (London, UK) involved simultaneous measurements of time-resolved velocity and temperature obtained by LDA and numerically compensated, fine-wire thermocouples in the near wake of a premixed turbulent flame. These experiments were performed to quantify the relative magnitudes of the terms involving the mean pressure gradient and Reynolds stresses in the turbulent kinetic energy and heat flux equations in strongly sheared, high Reynolds number reacting flow. What was found was that the interaction between the gradients of mean pressure and density fluctuations represent a large source term in the transport equations for the turbulent heat fluxes and exercise an important but weaker effect on the turbulent kinetic energy.

Modeling

The remainder of the presentations was concerned with various modeling studies which I will not describe in detail. I would like to say, however, that I was left with the clear impression that the modeling of turbulent combustion is at a relatively primitive stage, with the various scales and regimes of combustion just being identified and the important parameters by which the various regions are delineated being the subject of active discussion. Combustion produces a rich variety of length scales which cannot be modeled by a single length scale turbulence model such as the k-ε turbulence model. The paper by R. Borghi (University of Rouen, France) suggested handling the diversity of scales by means of a Lagrangian intermittency model. N. Peters (University of Aachen, West Germany) suggested that conventional combustion models could be improved by acknowledging the small scales by introducing the so-called Gibson scale.

Conclusion

The understanding of turbulent combustion cannot be obtained without a thorough understanding of turbulence. Unfortunately, turbulence is no more well understood from a fundamental point of view than is combustion. To make matters even worse, the interaction between turbulence and combustion is a highly nonlinear one. Clearly, much remains to be done in this very complex and important field.

Reference

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5/11/87

Ocean Sciences

OCEANOGRAPHIC RESEARCH IN NORWAY

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

In March I spent about 10 days visiting the Norwegian oceanographic facilities to determine the extent of activity in Bergen, Tromso, and Oslo. These facilities included the Nansen Center and the Geophysical Institute, both associated with the University of Bergen; the Institute of Biology and Geology, a

marine sciences field station, the Auroral Observatory, and the Telemetry Center, all associated with the University of Tromso; Norske Veritas; The University of Oslo; and The Nansen Institute.

Bergen

The Nansen Center. The Nansen Center for remote sensing at the University of Bergen is a relatively young organization with new facilities and a new director. Ola M. Johannessen heads an organization of about 50 people, including professional and support staff, working with all aspects of oceanographic remote sensing. I spoke with two of these investigators, L. Pettersson and D. Kolster.

Pettersson is primarily interested in altimeter measurements, especially as utilized in the determination of the geoid. He has noted that existing altimeter data loses its validity in coastal regions apparently because the altimeter device takes a finite period of time to stabilize as it passes between high to low reflectance areas. The time constant of this change for the SEASAT altimeter is not known, but he is working on this for future systems such as TOPEX. Pettersson would like to use some of the basic data from SEASAT coupled with gravity anomaly data to determine the geoid with an accuracy on the order of about 10 centimeters.

Kloster is an image analysis expert who has just been hired by the Nansen Center. He had been working previously at the Christian-Michelsen Institutt analyzing IR data from NOAA satellites nine and ten. He is starting to apply this experience in both IR and visible data analysis to other projects at the Center.

During my visit there was a great deal of activity associated with planning a meeting for the Norwegian Coastal Shelf Experiment (NORCSEX) which is scheduled for March/April, 1988. This will be an attempt to make *in situ* measurements of wind, surface waves, currents, eddies, fronts, and internal waves at the same time as ERS-1-type sensors are flown from aircraft. The objective will be to study the relationship between these hydrodynamic phenomena and the electromagnetic signatures associated with them. Haltenbanken, a region off the coast of Norway at a latitude of about 55°N, has been chosen for this multinational effort which includes principal and coinvestigators from Norway, the US, West Germany, France, and Canada. It will involve as many as four vessels; two which have already been committed are Norway's R/V *Hakon Mosby* and the R/V *Planet*. In addition to the aircraft flying active and passive remote sensing devices, satellite overpass data will be utilized in the experiment. Planning meetings lasted for 2 days, and it appears that the experiment is well underway and should come off as scheduled next year.

A large number of the NORCSEX participating scientists were present, many of whom were leaving on the Marginal Ice Zone Experiment (MIZEX) cruise a few days after the meeting. One of these was Sharon Smith, from Brookhaven, who is one of the first biologists to actually go out on a MIZEX cruise. She is interested in chlorophyll concentrations occurring within eddies and whether the eddies contribute to the productivity of the regions where they are found. This is of some interest since eddies are apparently associated with the marginal ice zone.

The Geophysical Institute. The Geophysical Institute of the University of Bergen is divided into departments of meteorology, oceanography, and solid earth. A total of 80 staff members make up this institute with about 15 being in the Oceanography Department. I visited two of the people in this institute, Hernan Gade and Harald Svendsen, both of whom are working on the dynamics of fjords and estuaries. Gade has developed a working numerical model of fjord circulation for the Norde Fjord in conjunction with a British Scientist, Anton Edwards, from the Scottish Marine Biological Association. Gade, Svendsen, and Edwards are attempting to develop a model capable of resolving layers on the order of 10 cm thick, and are going through an intense measurement period in support of their model. The model includes runoff and wind stress and within the not too distant future will be refined from its present two-layer configuration to a three-layer form.

Svendsen is not only working on numerical models of fjords, but also on other circulation models. In addition, he is the present chairman of the Oceanography Department, and he told me about the department, whose resources include the research vessel R/V *Hakon Mosby*, which has an acoustic current Doppler profiler aboard and is capable of supporting extended as well as short cruises. Members of the department are working on projects involving the modeling of tidal driving forces; the effects of a possible hydroelectric plant placed on the fjord; polar studies of both north and south polar regions; coastal currents; Polar-Sea/Norwegian-Sea interactions; and a small lend-lease project involving the country of Mozambique.

Tromso

The city of Tromso contains the northernmost university in the world,

being at a latitude greater than 70°N. Even so, the Tromso harbor never freezes over, so it is an ideal staging location for expeditions into the Arctic. Such an expedition, of course, is the present MIZEX operation mentioned above.

While in Tromso, I visited the search vessel *Polar Circle*, which is being prepared for MIZEX participation. She is a converted seal hunting ship with a large rear door similar to that found in the bow of LST's. This door feeds into an open hold, suitable for carrying all sorts of gear. The vessel has the usual oceanographic facilities and, in addition, is capable of receiving satellite data directly at a low data rate. The vessel will be in communication with the Telemetry Station in Tromso, which will telemeter high-bit data to the ship. The *Polar Circle* left Tromso on schedule, along with the research vessel *Hakon Mosby*, which joined her after being outfitted in Bergen. They will be operating in the area of about 76°N, 3°E.

The University of Tromso. The University of Tromso has apparently been targeted by the Norwegian government to be a center of academic excellence of the Norwegian north, and it is receiving appropriate support for such a status. Although the university has a student body of only 5000, it includes colleges of arts and sciences, engineering, law, and medicine and, in addition, a number of different institutes. The University of Tromso also has a small field station that I visited. This field station includes an aquarium, open to the public only during summer months; a wet laboratory including a seawater constant flow facility; a number of research laboratories; a classroom; and facilities for maintenance of the university's research vessels. This field station is available to university staff needing field facilities and is also capable of supporting one or two visiting investigators each year.

The Institute of Biology and Geology of the University. At the Institute of Biology and Geology I spoke with Hans Christian Eilertsen about his work in arctic ecology. There is an ongoing program in marine arctic ecology with special attention being directed toward the Barents Sea and the water surrounding Svalbard. These areas are characterized by very high biological production rates and large commercially important fish stocks. For this reason the Norwegian Research Program for Marine Arctic Ecology (PROMARE) has been initiated. PROMARE started in 1984 and is planned to last for 6 years. It includes a number of researchers throughout Norway who are covering biological, chemical, and physical aspects, including mathematical modeling, of the arctic ecosphere.

Eilertsen's unique contribution to this program involves his belief that the Bals Fjord in northern Norway presents a small microcosm of the Barents Sea. Since the Bals Fjord is very close to Tromso it presents a natural laboratory for the Tromso investigators. They believe that the measurements they make and the models that are generated for the Bals Fjord can be applied directly to the Barents Sea. When this model is complete it will be interesting to see if, indeed, the relationship between these two ecosystems is as close as Eilertsen believes.

The Auroral Observatory and the Telemetry Center. The Auroral Observatory has been at Tromso for a long enough time to have acquired a well-documented and reliable data base for middle atmosphere constituent measurements. The staff has been measuring ozone for over 30 years, and as yet they have detected no large decrease in ozone content of the middle atmosphere in this region similar to that detected around the Antarctic.

Close by the Auroral Observatory is the satellite Telemetry Center. Located close to the North Pole it is ideally situated to receive data from polar orbiting satellites because it is possible to receive data on every pass at this particular location. One of the segments of the Telemetry Center is run by a four-nation consortium consisting of the US, Canada, France, and the Soviet Union. The Norwegians, of course, contribute the real estate.

Oslo

Veritas Offshore Technology and Services. In Oslo I visited three facilities. The first of these was Veritas Offshore Technology and Services (VOTS), a branch of Det Norske Veritas. Det Norske Veritas is an old company, having been formed in 1864 as a marine surveying group. In recent years it has diversified and has become one of the largest private companies in Norway, having 200 offices in 109 different countries. I met with the small group of just six professionals who form the oceanography, hydrography, and operational simulations group at VOTS. The head of the group is Finn-Erik Dahl; others in the group include G. Host, who is working in wave and current interaction; H. Skatun, working in meteorology and numerical modeling; A. Lohrmann, working in geophysical fluid dynamics, instrumentation, and data interpretation; B. Hackett, doing work in time series data analysis; and L. Roed, also working in numerical modeling and sea-ice modeling.

A particular project of interest to these people at the present time is the Norwegian Ocean Current Data Analysis Project (NOCDAP) where the relation between wave orbital motion and forces on structures is being quantified. They have also been working with current velocity profiles and trying to see what effect density stratification has on these. As a result they have developed a good current data acquisition and analysis capability.

Another project of special interest to them is the Ocean Data Acquisition Project (ODAP), which involves cooperation with SACLANT in acquiring wave and current data in large amounts. So far, they have managed to build up a 7-year string of current data. The last project described to me by this group was the Bottom Stress Experiment (BSEX) in which both currents and their effects on bottom-mounted gear are being studied. As a part of this project a new current meter, the high-resolution current profiler, has been developed. It is an acoustic device that looks at the phase difference between two returned acoustic pulses scattered from inhomogeneities in the moving fluid. It is capable of much higher resolution and a higher data rate than any other current meter available at this time. Unfortunately, when placed on the bottom, the first 70 centimeters of water above the bottom is unmeasurable by this device.

The University of Oslo. At the University of Oslo I spoke with Bjorn Gjevik of the Mechanics Department and Jan Weber of the physical oceanography group of the Geophysics Department. The Mechanics Department has a total of about 40 graduate students with four or five working on numerical modeling. One of the models being developed is of the Norwegian coast and consists of a coarse, general circulation model with a nested finer mesh model. They are also doing some work on the analysis of side-looking radar (SLAR) data taken from Norwegian aircraft over the North Sea when internal waves were present. There is still another group in the Mechanics Department analyzing surface wave data from Norwegian Shelf oil rigs.

The physical oceanography group is the largest group in dynamical oceanography in Norway and is primarily concerned with various aspects of ocean dynamics and modeling. Their various projects include: modeling of surface wave mass transport, atmospheric coupling of this transport, ice/ocean dynamics, and storm surge problems. In many of these areas the investigators are working with the Norwegian Meteorological Institute and the Veritas group mentioned above.

The Fridtjof Nansen Institute. The last stop on my Norwegian excursion was to the Fridtjof Nansen Institute. This institute was established at the home of Fridtjof Nansen (Arctic explorer, designer of the Nansen bottle and the *Fram*, and winner of the Nobel Peace Prize in 1921) as an independent research institute in 1958. It is engaged in the study of selected areas of international politics, the international energy market, ocean management, ocean mining, and polar matters. The staff numbers about 25, most of whom have a background in political science or economics. One of the more interesting things about the institute is the building in which it is housed. It was built by Nansen in 1901, and his family lived in it until after his death in 1930. In addition to setting up an oceanographic laboratory in the basement of the house with Helland-Hansen, the building served as a meeting place for local artists and literary figures. Today it stands as an active, working monument to Nansen. Although the building is not open to the public it was possible for me to see Nansen's original office and some parts of the laboratory that still remain intact in the basement.

Conclusion

I was very impressed by both the quantity and quality of oceanographic research being done in this relatively small country (population about 4.5 million). The people I spoke with exhibited a high degree of competence in their areas of expertise and a familiarity with work being done in the rest of the world. The facilities I saw were adequate and up to date, and, in many cases showed a marked homegrown influence. Probably due to the long tradition of oceanographic excellence along with the availability of funding (partly from the North Sea oil fields), ocean research is very active and very healthy in Norway. This is especially true in areas of Norway's direct interest such as those related to ice, polar studies in general, and fjords.

5/8/87

OVERVIEW OF MARINE SCIENCE ACTIVITY AT ISRAELI FACILITIES

by Jerome Williams.

Since Israel has a relatively long coastline compared to its size, one would expect some activity in marine science.

As a matter of fact, there is a great deal; both basic research in all aspects of oceanography and applied research directed at coastal processes, fisheries, and a whole spectrum of ocean engineering problems. The basic research is centered at the National Institute of Oceanography and the Hebrew University, with some ongoing work at the Technion and Tel Aviv University. Most of applied research is taking place at the Technion and the laboratories at Kinneret and Elat. I visited all these facilities with the exception of the laboratory at Elat.

The National Institute of Oceanography

The major oceanographic facility at Haifa is the National Institute of Oceanography (NIO); it is housed in a seaside laboratory that has been at the present location for about 15 years. The institute is a government-owned company, rather than an agency of the government, an arrangement which apparently makes for easier relations with foreign establishments. The government agency having cognizance of this company is the Ministry of Energy, and it supplies and oversees the distribution of about 30 percent of the institute's funding; the remainder of the funding comes from outside grants. Resources include a 100-foot vessel, capable of carrying 12 scientists, that has been used a great deal in the eastern Mediterranean.

As is typical of marine science groups, NIO's effort is organized into branches involving physical, chemical, geological, and biological interests.

The Physical Oceanography Branch. My contacts in the Physical Oceanography Branch were Arthur Hecht and Steve Brenner. This branch consists of six staff people, two at the Ph.D. level, two at the M.A. level, and two technicians. Brenner, the branch leader, just recently arrived from the National Center for Atmospheric Research (NCAR) at Boulder, Colorado, and brings some expertise in numerical modeling with him. He is presently working on a project in collaboration with the US Air Force in which he is trying to predict precipitation in various areas using sea-surface temperatures as a predictor.

Hecht, on the other hand, has been working with Allan Robinson of Harvard on the Physical Oceanography of the Eastern Mediterranean (POEM) project for some time. He has been collecting eastern Mediterranean data and analyzing it for use in the models being developed. The majority of Hecht's work is observational and because of this, he has developed a good data base for the eastern Mediterranean.

Present proposals include one for a cooperative venture with Egypt and the US (through Princeton University) to develop a circulation model of the Levantine basin. Another cooperative project is with the Desert Research Institute in Arizona to model the atmospheric boundary layer over the ocean. There is also work in progress to relate IR and visible satellite data to *in situ* data taken by Hecht in the eastern Mediterranean.

In the near future it is hoped that permanent moorings in the eastern Mediterranean can be instrumented and the data continuously telemetered to shoreside facilities.

The Biological Branch. The biological work being done at the institute is rather broadly based. A hyperbaric pressure facility is available, for example, in which the effects of pressure on living organisms is being studied. Another project involves the measurement of nutrients in conjunction with pollution monitoring efforts of the Chemistry Department. The major focus of the Biological Branch over the years, though, has been the development of an optimal strain of zooplankton for use as mariculture food and the development of different methods for preservation of these zooplankton. After 5 years of working on these organisms it is becoming clear that zooplankton are just too expensive to raise and maintain. Cheap, artificial food will have to be developed to make any such mariculture venture economically feasible on a commercial scale.

A new project involves the production of a particular strain of shrimp larva in the laboratory by genetic engineering using various hormones. The researchers are involved in the analysis of the effects of the hormones on the shrimp larva and in producing new strains of these growth hormones that are more effective and easier to use. Also in progress are the usual types of culturing experiments for both micro- and macroalgae with the aim of developing more suitable strains for use as food in mariculture experiments.

The Geology Branch. The Geology Branch is split into two groups: Marine Geophysics and Coastal Processes. The Marine Geophysics Group is using geophysical methods to study the basic geology of the eastern Mediterranean basin; while the Coastal Processes Group is primarily involved with sand budget studies along the eastern Mediterranean coast. Since the attempt is being made to relate longshore transport to various physical phenomena, such as long-shore currents and wave action, a great deal of wave directional spectra data are being collected. Pressure sensors, placed just before the

breaker zone in water depths of between 8 and 9 meters, provide about four measurements per day. Data from two separate stations are available, one string of 8 years in length, and one 4 years long. The Geolcgy Branch is also doing bathymetric and subbottom profiling using acoustic devices along with a magnetometer and underwater television, so that the subbottom data of different types may be correlated with various bathymetric features. Future plans include a project to measure the dynamic aspects of the beach profile by permanently mounting acoustic sensors on stakes driven into the bottom.

The Chemistry Branch. The Chemistry Branch of the Oceanographic Institute is primarily concerned with pollution studies. Therefore, it is a two-pronged effort; one is involved with monitoring of various pollutants, especially heavy metals, and the other has to do with the development of new techniques for these monitoring processes. At present these new techniques are designed to use instruments already available, such as the gas chromatograph.

Kinneret Limnological Laboratory. A branch of the Oceanographic Institute, not located in Haifa, is the Kinneret Limnological Laboratory located on Lake Kinneret (Sea of Galilee). At this laboratory there are a number of ongoing projects, but the major portion of the work is in development of aquaculture methods, and monitoring of major fresh water supplies to the lake for a long list of pollutants including various bacteria. There is also some effort to maintain a rather broad limnological research program. Lake Kinneret is the primary source of fresh water for the entire country of Israel, therefore it is monitored very closely. The major pollution problem in the lake appears to be caused by the Jordan River bringing agricultural nutrients into the lake. The Jordan River chemistry is different from that of the lake, strangely enough, with the lake having a high pH. This results in the precipitation of calcium phosphate, ridding the water of one of the primary nutrients. However, this material is on the bottom waiting to be redissolved at some time when the lake pH might change.

Another project of interest at Lake Kinneret involves the use of enzymes as indicators of nutrient stress. Microalgae are being studied as possible indicators of nutrient stress by monitoring the enzymes in the algae. Synergistic and competitive experiments with different trophic levels are being done at the same time, in the same tanks.

The Technions--Israel Institute of Technology

The Technion, also located in Haifa, is Israel's major technical university, having schools in engineering, science, and medicine. There are about 5,000 undergraduate students and about 2,000 graduate students in approximately 20 different departments. Spread among these departments is some oceanographic research of interest. The specific department that seems most active in the area of marine science is the Civil Engineering Department. I spoke with M. Stiassnie, who is a theoretician working primarily in wave dynamics. His interests fall within the areas of nonlinear interactions and stability of gravity and capillary waves; the use of floating breakwaters in limited areas; and the use of fractals in describing ocean surfaces, especially within wave-generating areas.

The Mathematics Department of the Technion also has one or two faculty members involved in research directed toward hydrodynamic processes. One of these is L. Merkine, who has been working in the general area of geophysical fluid dynamics for some time. His most recent work is involved with stability of baroclinic waves, nonzonal currents, boundary layer separation in rotating flow, and the characteristics of blocking flow reversal and strong jets in a rotating stratified fluid.

Associated with the Technion are a number of more or less independent institutes. One of these is the Coastal and Marine Engineering Research Institute. This institute is affiliated with both the Technion and the Haifa Port Authority. It draws some of its staff from the teaching faculty of the Technion and some are hired for research purposes only. The staff is presently doing work in coastal marine engineering, marine structures, and bed movement. Their previous areas of interest have included solar ponds and environmental impact studies. They have some good modeling facilities, and they believe they can accurately model many coastal processes with physical models, in many cases better than anyone else.

Some previous projects that have been successful include a rather extensive wave and current data set taken in a coastal environment and the development of a physical model for the thermal plume of a projected power station. In addition, the institute was responsible for the design of a coal unloading pier which involved a mooring system controlling movement of large, coal-carrying ships as the key factor in ship stability during unloading, rathe than the use of a breakwater to control wave input to the

area. This system is in use at the present time. They also have been testing different shapes of rip-rap elements and are able to do this with a sophisticated wave generation and measuring facility in their coastal processes tank.

University of Tel Aviv

At the University of Tel Aviv there are two departments in which people are doing work in the marine sciences. The first of these is the Mathematics Department, where I spoke with S. Itzikowitz. He has a broad background in underwater acoustics, including sound transmission through eddies, signal processing, and numerical modeling. His major interests, at the present time, appear to be in signal processing and the application of signal processing to areas other than underwater sound.

In the Department of Geophysics and Planetary Sciences, I spoke with Z. Ben Avraham, who has been doing bottom and subbottom charting and working with the geophysics of the eastern Mediterranean, the Dead Sea, Lake Kinneret, and the Gulf of Elat. He has many years of experience in the analysis of bottom and subbottom profiling data and has done a lot of work in seismic refraction profiles and similar studies. This work is of some interest to those countries bordering on the eastern Mediterranean since this part of the world is very active seismically.

The Hebrew University of Jerusalem

The major academic institution in Jerusalem is the Hebrew University. Within the university the group most interested in marine science is the Institute of Earth Sciences. This Institute is divided into three departments: the Geology Department, which includes ocean chemistry, biological oceanography, sedimentology, chemical and physical processes of the Dead Sea, pollution, and classical marine geology; the Physical Geography Department, which includes investigators interested in the problems of ocean processes, transport, and the effects of construction on natural processes; and the Atmospheric Sciences Department, which includes physical oceanography and dynamic and physical meteorology. The Director of the institute is Dr. A. Katz, who himself is an ocean chemist. He is interested in the heavier brines produced by evaporation, especially in the Dead Sea. He told me that future plans for the institute include efforts to improve the programs in physics of the atmosphere and hydrosphere, to strengthen the structural geology and tectonics areas, and to emphasize research in the upper mantle.

The Atmospheric Sciences Department. In the Atmospheric Sciences Department, I spoke with A. Cohen, head of the department. His area of expertise relates to the propagation of electromagnetic energy through the atmosphere. He is particularly concerned with the effect of particles on laser and radar propagation through the marine atmosphere. By measuring the humidity profile using LIDAR he hopes to model the evaporation duct which affects radar transmission. This is not too much of a problem with high-flying targets, but with low-altitude targets or ships it can be very serious. Since there are measurement problems, the observational program is being supported by attempts to produce a mathematical model which might supplant a dense measurement grid. In order to do this they are taking data using both horizontal and vertical LIDAR with up to 40-km range. The methodology being utilized is the Raman-shift technique, which is unique to the particular substance being measured. The department is looking toward concentrating its future efforts in two specific areas. These are atmospheric physics including cloud physics and remote sensing, and air-sea interface studies including the dynamics of the ocean and atmosphere.

Another investigator in the Atmospheric Sciences Department with whom I spent some time is N. Paldor, a geophysical fluid dynamicist. He is concerned with various aspects of frontal conditions in the ocean, especially with the relationship between the surface signature and the depth profile in a frontal region. He has worked in the Gulf of Elat and the eastern Mediterranean using remote sensing data in conjunction with *in situ* physical oceanography data. The frontal problems of particular interest to him are those involving nonlinear frontal dynamics. At this time he believes he can predict the amplitude and the wave length of sea-surface temperature meanders along surface frontal regions, as well as inferring water column characteristics below the front.

Geology Department. The last person I spoke with at Hebrew University was B. Luz, who is in the Geology Department, but who is also the new Director of the Marine Laboratory at the Gulf of Elat. In previous years this laboratory, governed by an interuniversity governing group, was primarily concerned with biological oceanography, but now Luz has been given orders to expand into other fields.

Newly acquired by the Elat laboratory is a 21-meter research vessel which was just in the process of being delivered during my visit. This vessel will be capable of working in the Gulf of Elat and the Red Sea, carrying up to 20 scientists for 1 day or about eight scientists

on overnight cruises, at a cost of about $1000 per day. The laboratory itself is well equipped for marine biology, microbiology, chemistry, and physical studies. It is in a semi-tropical environment, and has a working meteorological station. Luz encourages visiting scientists to use these facilities. More information may be obtained from him at the Institute of Earth Sciences, Hebrew University of Jerusalem, Jerusalem 91904 Israel.

The Geological Survey. While in Jerusalem, I also visited the Geological Survey, a government agency also under the Department of Energy. My host, John Hall, showed me some of the excellent facilities he uses for analyzing and processing bathymetric, acoustic, gravimetric, and magnetic data and producing charts. Hall has produced an Arctic bibliography and is now working on one concerning the Red Sea and the Mediterranean.

Conclusions

Generally speaking, both individual scientists and scientific facilities I visited were of very high caliber. This is not too surprising since the Israeli government strongly encourages each investigator to spend a large portion of his professional life studying and working in non-Israeli facilities. I found that the typical pattern for an Israeli marine scientist was to either get his Ph.D. in the US, spend his postdoctorate years there, or both. Evidently, unless this pattern of some non-Israeli involvement is followed the chances for advancement, or even obtaining a position in Israel at all, are almost nil. Sabbaticals are given every seventh year to academic investigators and these must be spent in a foreign country. In addition, the summers are usually spent working in a foreign environment. Consequently, the influx of information from the US and other scientific world leaders into Israel, and the influence of American and European investigators on Israel is very great. With this strong influence comes the conviction that the use of modern equipment is a necessary edge to accomplishment of research so that Israeli laboratories were very well stocked by European standards. For a small country such as Israel the amount of active research, the wide diversity of fields covered, and quality of the research being done appeared to me to be exceptional.

4/29/87

Physics

SCANNING TUNNELING MICROSCOPY IN MADRID

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

Scanning tunneling microscopy (STM) is an exciting new tool for the study of surfaces of all kinds, often revealing details with atomic resolution. Based on the quantum mechanical tunneling effect, it was discovered only a few years ago at the IBM Laboratories in Zürich, Switzerland, and its application grew very fast in European circles. Almost every place I visited in the past 2 years, has already built a machine, usually a product of good graduate thesis work. In fact, to me, the most amazing feature of STM is its incredible simplicity (it can be constructed by almost any laboratory which has a simple workshop).

While many research centers built STM systems for specific uses, there are only a few real centers or groups evolving; one of them is at the Department of Fundamental Physics, part of the 15-year-old Autonomous University of Madrid (Autónoma). The head of the group, Professor N. García, is essentially an internationally known, well respected theoretical physicist, which in itself in unusual in the STM area. His assistant, an enthusiastic and mature scientist with very broad scientific curiosity is a skilled experimental surface physicist, Professor A.M. Baró (who actually showed me around). There is, presently, only one more doctoral group member, but six fine research students complete the enterprise. The research is also externally supported, originally by IBM, now to a large extent by the Spanish Government central research funds. There is also a fruitful cooperation with the Department of Chemical Engineering, Purdue University, Indiana.

General Description

The first STM built by the group looks like a gerrymade home appliance. It has a very simple mechanical damping system (utilizing eddy currents) and it is operated mostly in the normal atmosphere (even though mild evacuation is possible). The tungsten tip is moved in all three directions by a ceramic piezoelectric tripod of rather awkwardly large

dimensions, which ultimately limits stability. Yet, in the first experiments with this simple machine the group achieved an international "first": they succeeded in demonstrating that STM can be used for determining the three-dimensional topography of noncrystalline biological materials (they used the bacteriophage ϕ29 virus). The specimen was deposited on the (conducting) surface of pyrolitic graphite. The measurements were done at normal atmospheric pressure and room temperature, giving a vertical resolution of between 20 Å and 1 Å. I understand that the mechanism of the quantum mechanical tunneling from organic macromolecules is still not clear.

A later STM model built by this group uses a much smaller tripod steering mechanism and more sophisticated vibration-avoidance structure which consists of a series of metal plates isolated from each other by suitable elastic minirollers. This system is microprocessor-steered and can be operated in high vacuum. (The approach is to maintain a constant tunneling current, by moving the tip appropriately in the z-direction.) The evaluation and visualization of the measurements can be done by computer (via data logging), even though a direct strip chart recorder is also used in some simpler experiments.

Another machine, currently in the early construction stage, will use not a horizontally positioned tip but rather a vertical one, so that the sample can be laid out horizontally, allowing for the immersion of the surface into a liquid. The motion of the tip will be controlled, presumably, by one of the incredible modern micrometer screws which allow 0.1-µm accuracy (or more, if properly magnified by some leverage-device).

The Autónoma group has two more equipment-building activities underway.

The first aims at a sophisticated STM which will allow the use of an ultrahigh vacuum system. Such operation is, of course, needed if, for example, sensitive semiconductor device surfaces are the object of study. To my surprise, these scientists found that it will be better to install the system on the ground floor than in the basement: studies show better stability there, presumably by avoiding interference from other, heavy, surface physics equipment in the basement.

Finally, the most ambitious equipment development project is the combination of an ultrahigh-vacuum STM device with a modern scanning electron microscope. (The latter was--as of October 1986--on its way from Japan.) The idea is that by this combination one will have an experimental tool that combines the wide field of vision of the scanning electron microscope with the high resolution of STM.

An Example of Current Research in Electrochemistry

I concentrated above mainly on the description of equipment and facilities because a detailed summary report of research results can be found easily in two special issues of the *IBM Journal of Research Development* (the "Lech Conference" issues: the first came out in September 1986, the second is in the 1987 volume). I only call special attention to two increasingly active research efforts. One is the measuring of surface roughness (local periodic variations or defects) that cannot be seen by using a profilometer. The second is work on observing the tunneling effect even through a covering layer of 160-µm oxide. (In this case, the voltage applied to the tip must be rather high and operation in vacuum becomes mandatory.)

Next, as an example of work in progress, I give a brief report on research oriented to applications in electrochemistry.

It is now known that the surface of some metals (Pt, Au, Rh, Pa) which are of considerable interest in catalytic and electrocatalytic processes, can be preferentially oriented by a procedure called electrochemical faceting. The Autónoma scientists contributed significantly to this new field by having made the first "real space" observation of electrochemically faceted (100)-Pt electrodes with STM, achieving nanometric resolution. The main result of the study is that it confirms the existence of the faceted surface, displaying clearly the flat parts surrounded by ridgelike structures. Cluster formation in the initial stages could be observed; subsequently this develops into a preferential orientation. The Autónoma researchers (who cooperated in this project with the National University of La Plata, Argentina) think that this is evidence to show that faceting occurs through a nonselective electrodissolution/electrodeposition process, involving probably the fast diffusion of metallic species in either the electrolyte or on the surface.

Another related paper (submitted to the *Journal of the American Chemical Society* in early September for publication) reports on the correlation between catalytic activity and surface microtopography. While this may not sound surprising, the point is that the careful observations give support to a structural model for activated electrode surfaces. The special feature of this model is that it indicates a volume under the surface with

a pebblelike structure which allows electrocatalytic processes to occur virtually free of diffusion relaxation contributions under usual voltage/current conditions. I would like to note here that García wrote a substantial review article on STM, with strong emphasis on his current interests on the active use of STM in the area of surface modification of metals and materials machining. This paper is scheduled to appear in the late summer of 1987 in the Europhysics Journal *Physics in Technology*.

Future Goals

I am impressed by the plans of the group for future development because, apart from more intensive work envisaged in a broad area of practical specific problems (ranging from semiconductors to biological and biomedical samples), the scientists consider it to be their task to shed more light on the better understanding of the STM process. For example, I was told that the relationship between the role of surface topography and local electronic structure is not well understood--and clearly this is a problem to be solved before a reliable evaluation of STM "pictures" can be undertaken.

The Autónoma group at Madrid deserves serious attention from American colleagues.

5/29/87

ULTRAHIGH-RESOLUTION LASER SPECTROSCOPY SERVES BASIC PHYSICS IN MUNICH

by Paul Roman.

Professor Theodor W. Hänsch is one of the most highly respected laser physicists of the younger German generation. Soon after he received his Ph.D. in Heidelberg, he went to Stanford University in California for a "brief visit" which turned out to last 16 years. However, in 1986 he was offered one of the then-vacant chairs in experimental physics at the University of Munich and, in addition, the newly created position of (the fourth) codirector at the Max Planck Institute for Quantum Optics (Garching, near Munich). He then returned to his native country and is now making fast progress in building up two top-notch laboratories (at the university and at Garching).

During my visit in February (see *ESN* 40-8:287-290 [1986] for report on my last previous visit), Hänsch told me that he deliberately plans doing different research at the two laboratories. At the university, he will establish pioneering research which needs no grand instrumentation and which will also serve the masters' and doctoral level work of students. At Garching, the work he plans will utilize the very high-level, sophisticated support structure of the Institute.

Actually, the laboratory at the university will surely not be a run-of-the-mill-type either. They have already built one (and are constructing several more) scanning tunneling microscopes (STM's), which Hänsch and his coworkers want to employ in conjunction with unique laser-spectroscopic techniques and other optoelectronic studies. In this area, Hänsch has the good luck that, Dr. G. Binnig, from the IBM Research Laboratory at Zurich and coinventor of the STM and sharer of the 1986 Nobel Prize in Physics, was recently named Honorary Professor at the University and is working as a guest in Hänsch's division. The story is that IBM is going to open a big (150 staff) research laboratory in Munich within the next 2 or 3 years, and, in anticipation of this enterprise, Binnig has already moved to Munich under special auspices. Of course, this also means the influx of certain (appreciable!) research funds from IBM to the university's experimental physics program.

Following are some of Hänsch's planned STM-related studies at the University:

- Using the already functional fast-scanning STM, Hänsch wants to investigate electronic or vibrational laser-excitation of individual molecules. He believes that a combination of laser light and tunneling current (collisional) excitations will lead to unusual atomic states and new phenomena.
- It has been observed that Langmuir-Blodgett films on a substrate, consisting of two molecular layers with a metal ion in between, give rise to a tunnelling current, whereas theoretically they should not. Hänsch thinks that an optical analogy may solve the puzzle: the system can be compared to a Fabry-Perot device, in which, despite the two mirrors, a single photon may pass through, in the resonant condition. Laser spectroscopic observation of the film during the tunneling may verify this possible model.
- Binnig pioneers a new kind of methodology, called atomic force microscopy (AFM), which uses the same arrangement as a STM but where no current flows and where an image is derived from the van der Waals forces acting on the tungsten tip. Hänsch plans to use

laser excitation of the surface molecules in order to alter the van der Waals forces and see the effect on single molecules.

- Inelastic processes can lead to strong nonlinearities of the tunneling current mechanism. Large enhancement in the efficiency of nonlinear mixing of optical and microwave frequencies can be expected. These completely new phenomena are also a project for the future, and hold the promise of providing new means of the measurement of optical frequencies.

Summarizing his excitement about STM-related work, Hänsch pointed out that an STM experiment is cheap, easy to do, and thus, eminently suitable for a university environment. Incidentally, apart from STM work, he also plans new studies at the university with optically nonlinear crystals--this in order to continue earlier work on the generation of coherent UV radiation with a dye-laser source.

With my one-time background of theoretical physics, I found Hänsch's plans for his future laboratory at the Garching Institute even more exciting than those at the university; following is a brief review of these.

At Garching, Hänsch wants to continue to perfect his ultrahigh-resolution spectroscopy studies of the simplest of all systems: the hydrogen atom. This work has tremendous importance regarding the very foundations of quantum physics. On this simplest atom, rightly-designed experiments can probe the validity of quantum electrodynamics with unexpected accuracy; and the use of ultrahigh-resolution spectroscopic methods may give even better insights than do "brute force studies" done with high-energy accelerators. In addition, the appropriate laser-spectroscopy experiments can yield atomic and elementary-particle constants with thus far undreamed-of accuracy. Typical examples are: the Rydberg constant, the ratio of the electron and proton mass, and the electromagnetic form factor (charge distribution) of the proton.

In his past work, Hänsch used Doppler-free two-photon spectroscopy for the 1S-2S transition, and obtained an enormous increase in sensitivity. This transition has an extremely narrow line width of only 1 Hz. The essence of the arrangement was to produce the necessary photons at exactly 243-nm wavelength by means of nonlinear frequency summing in KDP of an argon ion laser and a dye laser output. The crystal was placed in a resonant ring-laser cavity. The extracted 243-nm radiation was then focused into a chamber through which H atoms were pumped and which was placed in a second, linear, "storage resonator."

One of the current improvements is based on avoiding the cumbersome frequency mixing of two lasers: indeed, with recent novel nonlinear crystal materials it appears feasible to use only a single (tunable) dye laser and employ high-efficiency frequency doubling.

Further plans to achieve higher spectroscopic resolution of the 1S-2S transition involve extreme cooling of the H atoms. One idea is to cool them first by advanced, but classical, cyrogenic techniques, and then catch them in a magnetic trap. (This technology is developed in cooperation with Professors N. Kleppner and D. Pritchard at Massachusetts Institute of Technology.) The probably more efficient method of laser cooling is rather difficult in the case of hydrogen: one must use the Lyman α-line, at 121.5 μm. But Hänsch thought of a method to get coherent radiation at exactly this awkward wavelength. He will use a tunable dye laser and arrange for frequency tripling in Hg vapor. To make the conversion efficient, he will use a ring resonator arrangement.

Yet another frontline idea to improve resolution is the following. Suppose you have sufficiently cooled and trapped H atoms. Let them shoot up vertically through a slit, and allow them to fall back under the effect of gravity. (If the cooling took the atoms down to a temperature of a few milli-Kelvins, the parabolic trajectory of the H-atoms will take them to a height of perhaps less than a meter or so.) Then, letting the rising and backfalling individual H-atoms pass through a fixed standing wave pattern (from a laser + mirror system), one can do an optical 2-photon Ramsey-spectroscopy. Hänsch claims that, with this arrangement of an "atomic fountain," a line resolution of only 1-Hz width (the "natural width limit") will be perfectly possible.

It is well known that nuclear-size, form-factor effects, and difficult-to-calculate higher order radiative corrections plague all attempts at checking the accuracy of quantum electrodynamics. But Hänsch suggests a good solution: these perturbing effects can be eliminated (cancelled) if two (or more) transitions are observed simultaneously. Hence, one of his future plans involves the study of the 1S-2S transition, together with the observation of transition from the metastable 2S state to some high-lying Rydberg state.

Hänsch concluded the interview with the explanation of an almost science-fiction-like proposal, an experiment which, he claims, could be done with a

2- or 3-year preparation. It concerns the ultrahigh-resolution spectroscopy observation of 1S-2S, 2S-Rydberg states, and other similar transitions--now not in hydrogen (as sketched above) but in anti-hydrogen! (which, of course, consists of an anti-proton and a positron). And this could be done without even being near a huge high-energy particle facility. He says that the anti-hydrogen could be prepared (with the now already published methods that have been used at CERN) and, putting the "stuff" into a Penning trap, transported by plane or train to the laboratory where the ultrahigh-resolution laser spectroscopy (using the same methods as indicated above for regular H) would be done...Good Luck! If it works, an utterly novel test on quantum field theory will have been performed--and we may be in for a surprise.

Clearly, in Hänsch, Munich has gained an imaginative, hard-working, high-aiming, top-notch physicist who is using his highly developed experimental skills for the unraveling of some of the most basic questions one can raise in the domain of fundamental quantum theory and, more specifically, quantum electrodynamics. When asked for reasons that made him give up his high position at Stanford and go back to Germany (reverse brain-drain!), Hänsch said (among other things) that "some of our work really needs more support and continuity than is available under the current tight budget restrictions for atomic physics research at American universities." Food for thought, I think!

5/22/87

News and Notes

NEW TECHNICAL DIRECTOR AT ONRL

At about the time this issue of *ESN* is distributed ONRL will be welcoming Dr. James E. Andrews as its new Scientific Director. He will replace Dr. David L. Venezky, who will have completed his London tour and returned to the Chemistry Division at the Naval Research Laboratory in Washington, DC.

Dr. Andrews comes to ONRL from the Naval Ocean Research and Development Activity (NORDA), NSTL, Mississippi, where he has served as Technical Director since 1981.

Since taking his degree in Oceanography at the University of Miami in 1967, Andrews has worked and published primarily in the fields of marine geology and geophysics. His most recent work before his appointment at NORDA involved research in the application of military sonar systems to long-range side-scan mapping; the deep ocean environment and its influence on sediment and manganese nodule deposits; evaluation of the deep ocean environment as a site for a large (109 ton) cherenkov detector (DUMAND); development of submarine drainage patterns around the Hawaiian Islands, influences of man's activities on these, and their potential as pathways for waste disposal. This work was supported by the Office of Naval Research, the National Science Foundation, the State of Hawaii, NOAA, and US industry.

C.J. Fox
6/3/87

COMPUTER-ASSISTED PERSONALITY ASSESSMENT DEVICE NOW AVAILABLE

Recent innovations in free-response format computer-assisted personality assessment have resulted in an assessment device that is now available for use. Developed by Drs. Arnold Bohrer (Psychology Section, Belgian Army) and Paul DeBoeck (Catholic University of Leuven), this approach presents subjects with a blank page, and asks them to describe themselves by listing 10 trait-descriptive adjectives, of their choice. These descriptions are assigned scores on a number of dimensions, and the resulting scores are used to characterize the subject.

How is this done? First, a large dictionary of trait descriptors was developed in the English, French, and Dutch languages. (The original Dutch version contains 3000 adjectives.) After gathering every descriptive adjective they could, the test developers asked judges to rate these words on five-point scales along eight dimensions. The particular dimensions were chosen because they were thought to represent some of the most important aspects of personality. The dimensions are: extroversion, agreeableness, conscientiousness, neuroticism, open-mindedness, leadership, creativity, and social desirability.

Reliability and validity studies conducted on the resulting free-format personality measure have produced very encouraging results (see Claeys et al.,

1985). Interjudge reliability in assigning scores to the various dimensions was greater than 0.90. Likewise, 1-day test-retest reliability figures were also impressive (r_{tt}=0.75), and test administrations separated by 1 year resulted in a very strong stability coefficient (r_{tt}=0.50).

Validity work, too, has been undertaken, with good results. Concurrent validity studies have shown that the ratings subjects obtain on the seven dimensions of the instrument correlate well with established tests of relevant characteristics. Additional studies relating peer and parent ratings with scaled outcomes also have shown strong validity coefficients. Finally, predictive validity studies carried out in the Belgian Army demonstrated that the dimensions of leadership, conscientiousness, and social desirability were predictive of success in the officer selection process.

The free-format approach has much to offer; however, it also is susceptible to certain pitfalls, and these should be noted. First, internal consistency of the results can be attenuated by a respondent's idiosyncrasies of trait definition. Such can be overcome by adopting an analogue to the item-total correlational approach used in the development of more standard fixed-format measures.

A second issue that must be addressed is the relative importance of the order of production of the self-descriptors. Do items that appear at the beginning of respondents' self-descriptions carry more meaning than those appearing later, or vice versa? This issue can be investigated through a process in which the values of the first-appearing, second-appearing, etc., adjectives are correlated with the total dimension score across all subjects. If order makes a difference, then the item-total correlation across different trait descriptors should illustrate this outcome.

Problems with the interpretation of the midpoint value also are important to consider in this approach. Recall that each trait descriptor is rated on a five-point scale. The midpoint value (3) is defined to mean either that the trait is irrelevant to the dimension or that it has an intermediate value on the dimension. There is a very major difference between irrelevant and intermediate, but the approach to this point does not make this distinction.

Finally, there are problems of the social desirability of self-descriptive adjectives that must be addressed. It is unlikely that a person will employ very negative self-descriptors, even if he or she deserves them. Does the bias toward presenting one's self in the best possible light seriously bias the outcome of the free-format approach?

These problems need to be addressed to enhance the quality of a very interesting measurement approach. Indeed, the approach is so important that it has the potential to revolutionize measurement in personality. As suggested briefly here, the problems can be solved, or avoided, if proper care is taken. A newly available ONRL Report (7-016-R) provides comprehensive details of the means by which such solutions might be attempted, along with a more complete description of the new measurement technique. For those interested in developing their own free-format method of assessment, these recommendations might prove very useful.

Reference

Clayes, W., P. DeBoeck, W. Van Den Bosch, R. Biesmans, and A. Bohrer, "A Comparison of One Free-Format and Two Fixed-Format Self-Report Personality Assessment Methods," *Journal of Personality and Social Psychology*, 49 (1985), 1028-1039.

William D. Crano
6/11/87

UPDATE ON BIOTECHNOLOGY RESEARCH IN WEST GERMANY

Currently, the West German government is providing subsidiary sponsorship--helping industry to help itself--for more than 40 research projects. These are all particularly long-term and high-risk projects which it would not be possible to implement without some government aid. The program for government sponsorship of biotechnology was initiated in 1985. To date, 16 companies in West Germany are taking part in the sponsored projects. The Federal Ministry of Research and Technology (BMFT) has budgeted DM17 million (about $10 million) in 1987 for this purpose. Some examples from the project sponsorship provided by the BMFT were issued at the biotechnology conference held in Düsseldorf, West Germany, from 17 through 19 March 1987.

As stated by H. Riesenhüber, Federal Minister for Research, success in combatting acquired immune deficiency syndrome (AIDS) involves closing gaps in our knowledge, especially in immunology and virology, and building up appropriate research capacity. The BMFT's sponsorship is concentrated on:

- Immune prophylaxis of HTLV-III/LAV infection
- Therapeutic concepts for HTLV-III/LAV infection
- performing multicenter therapeutic studies
- Developing and testing suitable models for studying AIDS
- Work on increasing our knowledge of the immunology and virology of AIDS.

According to Riesenhüber, current research has already made its initial contributions to understanding AIDS. It has also become apparent that the complex effects of AIDS on the human immune system represent a difficult task for research and development programs. The federal government will therefore use a wide range of means of sponsorship to foster the most promising methods of attack and the necessary cooperation between researchers.

Various substances are produced in the human body itself for defense against potentially damaging intruding microorganisms or substances. One group of these immunologically active substances is the lymphokines-proteins soluble in blood, which stimulate and control the defence by white blood cells against viruses, bacteria, and other pathogens. Various types of cells involved in this immune reaction of the body produce lymphokines, examples of which are interferon, interleukines, B-cell growth factor, and tumor necrosis factor. These lymphokines in turn affect the activity of other cells and thus the course of the immune response. It is thought that up to 50 lymphokines control the complicated immune system. Apart from interferon, however, few of these substances have yet been characterized, synthesized, and tested for their effectiveness by means of clinical trials. Future research aims include:

- Clarifying the immunological function of a lymphokine in the organism
- Characterizing the target cells and their receptors
- Assessing the therapeutic value of combinations of several lymphokines.

BMFT also attaches increasing importance within its sponsorship program for biotechnology to work on replacing animal experiments in research and in product testing. The research projects concentrate on using microorganisms and animal and human cell cultures and on biochemical models and computer-aided modeling. The development and testing of *in vitro* methods includes studying pharmacological mechanisms of action, testing chemical substances for mutagenic action, producing vaccines for use in the treatment of cancer, and developing test models for immune research.

New starting points in work already sponsored by the federal government on "regrowable raw materials" are primarily expected from introducing and applying new biological methods in practical plant breeding, but also from new chemical and biotechnical methods in conversion technology and from new ideas for integral utilization of biomass. Research such as this presupposes successful basic research, which must start with plant breeding and with the applications of biomass and biomass products. Once the products are found, primarily from plants, processes and production technology for using them chemically or to produce energy must be developed. Therefore, the topic of plant breeding and biomass includes sponsorship projects ranging from applications-oriented basic research through to first-time industrial developments.

The BMFT considers that the following topics promise high scientific and economic innovation potential:

- Transferring and applying knowledge and processes from genetic engineering and *in vitro* culture methods to plant breeding questions
- Improving the production of plant material which stores sugar, starch, oils, fats, and proteins and improving the composition of such material in biomass production
- Increasing the utilization of natural resources by the plant (light/photosynthesis, water balance, ion balance)
- Developing new biotechnological and physicochemical methods for using biomass as raw material and for generating energy
- Developing integral concepts for utilizing biomass.

The main emphasis of the sponsored work is on long-term benefits. BMFT is willing to support efforts aimed at placing research and development on new plant breeding methods on a broader basis, to reanimate research on carbohydrates and fats within West German universities, and to include topical research on the relationship between structure and properties of materials. The sponsorship concept also envisages opening up alternatives to plant production in agriculture and to the use to which agricultural products are put; this means in particular, the Ministry expects to strengthen the competitiveness of West Germany's agriculture and forestry, manufacturing industry, and medium-sized privately owned plant breeders.

Riesenhüber stated that the sponsorship concept does not conflict with the federal government's existing responsibilities for agriculture and forestry and with industry's primary responsibility for ensuring that its competitiveness is maintained by research. The primary aim is to strengthen the scientific and technical potential in the institutions and centers of basic and applied research together with the research potential of the plant breeders and industry to solve priority research and development tasks in research on plant-based biomass and its utilization. The projects are therefore intended to be implemented in close, specializing cooperation between institutional, industrial, and agricultural research. The program also provides for specific measures to strengthen the transfer of information and technology (through reports, status seminars, and other measures), especially for the benefit of small and medium-sized private firms.

Claire E. Zomsley-Neurath
5/24/87

NEW JOURNALS IN BIOLOGICAL SCIENCES

Four new journals in biological science have recently been announced. Following are the details.

Proteins: Structure, Function and Genetics

Important advances are being made in all aspects of the research on protein molecules and the genes that encode them: Recent developments are having a major impact on the rate and ease with which the three-dimensional structure of proteins and protein complexes can be determined...There are new molecular genetic methods for introducing site-specific mutations and for obtaining high-level expression of proteins...New insights into the relationships between protein structure and function are being provided by the increased power of computational analysis and advances in the understanding of the physical chemistry involved...Development of knowledge of primary and secondary structure of nucleic acids and the proteins which interact with them is yielding a new understanding of the ways in which gene expression is controlled.

The aim of the new journal, *PROTEINS: Structure, Function and Genetics*, is to keep readers abreast of significant advances and offers investigators a vehicle for reporting their important new work. The journal concentrates on advances in all areas of protein research (structure, function, genetics, computation, and design). Specific areas covered include:

- Structure-function relationships of proteins and inhibitors
- Structure determination, including discussions of new techniques
- Design of new proteins and small molecules that can interact with them
- Studies of the interactions between proteins and nucleic acids
- Modifications of proteins by altering the genes that encode them
- Modifications of proteins by chemical means
- Results and methods of computational analysis for protein structures and function.

The journal welcomes full-length articles reporting new experimental and theoretical results. In addition, each issue includes review articles. The Editor-in-Chief is Cyrus Levinthal (Department of Biological Sciences, Columbia University, New York). The composition of the editorial board is international, including scientists from the US, the Netherlands, France, UK, Japan, Canada, Sweden, West Germany, and Switzerland. The journal is published monthly by Alan R. Liss, Inc., 41 East 11th Street, New York, New York 10003, US). The cost of the journal per year is $225 (institutional rate) and $90 (personal rate).

Molecular Microbiology

The first issue of *Molecular Microbiology* will be available in July 1987. The publishers are Blackwell Scientific, P.O. Box 88, Oxford, UK. Volume 1 will be published in three issues at a special introductory price of $86.50 (North America and Japan), post-free. Volume 2 (1988) will be published in six issues at $189.00 post-free.

Molecular Microbiology will publish high-quality research papers addressing any microbiological question at the molecular level. The journal will include papers describing the molecular biology, genetics, and biochemistry of any microorganism, prokaryotic, or eukaryotic. The editors are C. Higgins (Department of Biochemistry, University of Dundee, UK) and G. Schoolnik (Division of Infectious Diseases, Stanford University School of Medicine, California). Articles in the area of molecular pathogenicity will be particularly welcome. Papers in the field of biotechnology will be considered, but only where they address fundamental biological questions. Shor' reviews will

also be published in areas where rapid advances are currently being made. Many, but not all reviews will be invited; authors with an idea for a review should contact the editors. Also, DNA sequences published in *Molecular Microbiology* will automatically be deposited with the EMBL (European Molecular Biology Laboratory) sequence data base.

According to the publishers, the journal will ensure:

- Rapid publication (within 12 weeks of acceptance
- No page charges
- Reproduction of the highest quality
- Provision of free reprints
- Expert refereeing of papers.

The membership of the editorial board is international, representing scientists from Switzerland, the UK, US, West Germany, Sweden, Ireland, Italy and France.

Computer-Aided Molecular Design

The *Journal of Computer-Aided Molecular Design* has been established to provide a forum for disseminating information on both the theory and the application of computer-based methods in the analysis and design of molecules. The aim of the publishers (ESCOM Science Publishers, P.O. Box 214, 2300 AE Leiden, the Netherlands) is that the journal should become a premier source for reporting computer simulations in chemistry, physics, and biology.

The scope of the journal encompasses papers which report new and original research and applications in the following areas:

- Theoretical chemistry
- Computational chemistry
- Computer and molecular graphics
- Molecular modeling
- Protein engineering
- Drug design
- Expert systems
- General structure-property relationships
- Molecular dynamics
- Chemical database development and usage.

The journal will also include a feature section, entitled Perspectives, where experts will be invited to comment on developments in various aspects of the fields covered by the scope of the journal. The use of color is encouraged, particularly for the reproduction of computer graphics displays. A minimum charge is levied on authors from commercial organizations but may be reduced for those in academic institutions. The subscription price for 1987, Volume 1 (four issues) is $141.50 plus $10.50 for postage and handling.

The journal is typeset and initially will be published quarterly, with a view to becoming a monthly publication when this becomes justified. There are no page charges to publish in this journal, and authors will receive 50 free reprints (black and white only) per contribution. All color reprints carry a charge.

Contributions on computer-aided molecular modeling studies in polymer materials and surface sciences as well as other molecular-based disciplines are particularly welcome to complement contributions from the pharmaceutical sciences. It is intended that the journal will communicate original research and applications in the use of computers in the analysis and design of molecular structure. Authors reporting the results of applications are encouraged to include predictions of structures and properties which can be computationally verified and experimentally tested. Submissions about new methods or theoretical formalisms should include discussion and the need for, and utility of, such approaches.

The Editors-in-Chief are:

For the Americas and Australasia--Professor G.R. Marshall (Department of Pharmacology, Washington University School of Medicine, St. Louis, Missouri).

For the UK--Dr. J.G. Vinter (Smith Kline & French Research Limited, The Frythe, Welwyn, Herts., UK).

For Continental Europe, the Middle East, and Africa--Professor H. D. Holtje (Department of Pharmacy, Free University of Berlin, Berlin, West Germany).

The editorial board is international in scope, including scientists from Australia, West Germany, the UK, US, the Netherlands, Yugoslavia, France, Belgium, and Switzerland.

Bioluminescence and Chemiluminescence

The aims and scope of the new *Journal of Bioluminescence and Chemiluminescence* is to provide comprehensive coverage of the fundamental aspects and applications of light-emitting reactions, both chemical (chemiluminescence) and biological (bioluminescence). The journal will publish original scientific papers, short communications, and review articles on fundamental and applied aspects of bioluminescence and chemiluminescence. It will also have a News and Events section which will contain details of forthcoming meetings, information on new products, and book reviews. A special feature of this journal will be a quarterly survey

of the recent world literature on bioluminescence and chemiluminescence.

Chemiluminescent and bioluminescent methods are used as research tools in many disciplines (chemistry, clinical sciences, environmental monitoring, microbiology) and the scope of the journal will reflect this diversity as follows:

- Instrumentation
- Fundamental studies
- Applied chemiluminescence
- Applied bioluminescence
- Luminescent immunoassay
- Luminescence in microbiology
- Phagocytosis
- Low-level luminescence.

The Editor-in-Chief is Dr. L.J. Kricka (Department of Clinical Chemistry, Wolfson Research Laboratories, University of Birmingham, UK). The North American editors are Dr. R.C. Allen (US Army Institute of Surgical Research, Fort Sam Houston, San Antonio, Texas) and Dr. H.R. Schroeder (Senior Staff Scientist, Ames Division, Miles Laboratories Inc., Elkhart, Indiana). The European editors are Dr. A. lundin (Research Center, Karolinska Institute, Huddinge University Hospital, Huddinge, Sweden) and Dr. F. Berthold (Laboratorium Professor Dr. Berthold, Wildbad, West Germany). The Japanese editor is Professor T. Goto (Nagoya University, Faculty of Agriculture, Nagoya, Japan). The editorial board is international in its membership; it is composed of scientists from the UK, US, West Germany, Japan, Canada, Italy, Israel, and Belgium. The journal is being published by John Wiley & Sons Ltd., West Sussex, UK, in four issues per year at a cost of $120 per year.

Claire E. Zomzely-Neurath
5/20/87

NEW TEST FOR RAPID IDENTIFICATION OF BACTERIA BEING DEVELOPED BY TWO ISRAELI SCIENTISTS

Finding the appropriate antibiotic treatment for a given ailment depends on the rapid identification of bacteria in clinical specimens. But available test methods are tedious and often require long periods of incubation.

According to a Tel Aviv University news release, Drs. Eli Sahar and Raphael Lamed of the university's department of biotechnology are now working on a rapid, automated method that can quickly identify, enumerate, and analyze the antibiotic sensitivity of bacterial microorganisms. It works by passing the bacteria through a focused laser beam that probes their optical properties.

Research has so far demonstrated the validity of the concept; testing has been done on a model system of urine infected with controlled numbers of *E. coli*. The determination of their antibiotic sensitivity has been accomplished in less than an hour. Identification of *Streptococcus Pyogenes*, common in throat infections, has also been done.

The new system will enable the physician to determine:

- The level of bacterial contamination in the analyzed sample
- The category of bacteria present
- The presence and number of leucocytes in the urine.

In addition, the physician will be able to perform, in approximately half an hour, a complete antibiotic sensitivity test in order to determine the best drug for those patients whose urine was found to contain pathogenic bacteria.

Future research will seek to apply the new system to many additional areas of microbial analysis:

- Bacterial identification of clinical specimens of saliva, blood, and cerebrospinal fluids
- Identification of bacteria in dairy and meat products
- Environmental bacteriological control of drinking water, sewage, and other infected wastes
- Quality control in the pharmaceutical and cosmetic industries.

The project will require approximately 2 more years of preindustrial research and clinical testing, for which funds are currently being sought.

C.J. Fox
6/1/87

HARWELL'S SONOCHEMISTRY SERVICE EXCITES CHEMICAL INDUSTRY

The UK Atomic Energy Authority's Harwell Laboratory has announced the launching of a unique collaborative research program into the use of ultrasound in chemical processing.

Called "The Sonochemistry Development Club," it aims to study the effects of ultrasound on chemical reactions to determine the principles of scale-up

needed to take the process from laboratory to plant.

Industrial interest in sonochemistry has grown dramatically over the past 5 years with the promise of increased chemical reaction rates, milder operating conditions, and improved product yield. The use of ultrasound (sonic waves having frequencies of more than 16 kHz) offers chemical manufacturers potential savings in time, energy, and raw materials.

Ultrasound causes cavitation and mechanical agitation of the liquid. Cavitation produces minute bubbles, which quickly collapse with explosive force and impart high stresses to nearby molecules. This localized violent activity increases contact area between phases, accelerates mixing, and generally increases the rate of chemical reactions.

A surprising number of companies, involved in a broad range of chemical processes, have shown a strong interest in the new club, and the backing of the UK's Department of Trade and Industry ensures that the research budget will be at least £150,000 (about $248,000).

For further information contact Dr. Terry Goodwin in the Chemical Technology Centre, Harwell Laboratory, OX11 ORA (Telephone 0235-24141 Extn 5058) or Dr. Rosemary Lee, Commercial Office, on extension 3025.

C.J. Fox
6/4/87

AN EUROPEAN CENTER FOR ARTIFICIAL INTELLIGENCE RESEARCH AND DEVELOPMENT

At the very edge of central Munich is a small but powerful think tank, apparently not well known by American researchers. It is an independent multinational European company, founded in 1984, incorporated in West Germany. The institute is called European Computer-Industry Research Center (ECRC); its official working language is English; and its Director is a Frenchman, H. Gallaire. ECRC is independent, yet legally "it is owned equally" by the Bull Group (France), International Computers Limited (UK), and Siemens A.G. (West Germany).

The major aim of ECRC is the development of basic theoretical know-how for the implementation of machine-assisted decision making. There are currently about 80 scientists and technicians employed, many of them on "loan" from one of the three owner-companies. Research is done on the fundamental concepts of artificial intelligence and on necessary software tools and computer architectures needed to support them. Areas currently studied are:

- Knowledge acquisition and knowledge representation
- Reasoning mechanisms
- Man-machine interfaces.

Practical motivation for focusing on these fields comes from tasks such as failure diagnostics, computer-assisted design of complicated systems, and integration of multiple functions/services/sensor systems.

The detailed formal research program covers four areas:

- Logic programing (both methodologies and tools; building of software prototypes)
- Knowledge bases (bridging the gap between classical databases and deductive systems)
- Architectures (especially parallelism, based on new languages, computational models, and execution models)
- Interactions (between user and decision support systems; decision explanation system. Special use of bit-mapped displays).

The Director says that ECRC "is intended to be the breeding ground of those ideas, techniques, and products which are essential for the future use of electronic information processing." The activities of ECRC "are intended to enhance the future competitive ability of the European information technology industry, and thus, complete the work of national and international bodies." These last remarks leave it open what sort of cooperation is intended--within or without the big European schemes, such as ESPRIT or EUREKA (but probably, within the latter).

Paul Roman
5/14/87

GALLIUM ARSENIDE RESEARCH AT STUTTGART'S MAX PLANCK INSTITUTE

A few months ago the Federal Ministry for Research and Technology (BMFT) of West Germany initiated a major cooperative research and development project in the area of GaAs-based devices, with the goal of catching up with the US and Japan in this area. It is important to emphasize that this project is a purely national undertaking and is not integrated

into any of the all-European high-tech programs such as ESPRIT or EUREKA. While it is still not a decided issue whether GaAs technology will ultimately replace Si technology, the BMFT was convinced that GaAs devices deserve serious interest because of two, quite well-known reasons: first, they have high promise for long-term development of integrated monolytic optoelectronics circuitry, and second, they hold the promise of ultra high-speed microelectronics.

Current activities in the program include the study and preparation of suitable substrates; molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) technology for GaAs systems; and actual construction of submicron structures of various types, including high-electron-mobility transistors and vertically operating heterojunction devices.

The cooperative program involves three participants: the Max Planck Institute for Solid State Research at Stuttgart, the Fraunhofer Institute for Applied Solid State Physics at Freiburg, and a group of industrial partners (including Siemens at Neuperlach, AG-Telefunken at Ulm, Telefunken Elektronic at Heilbronn, and the Wacker Company).

In late January, I visited what appears to be the principal player in the cooperative at the level of basic research--i.e., the Max Planck Institute for Solid State Research at Stuttgart. This institute (sharing facilities, in part, with the Physics Division of the Max Planck Institute for Metal Research) has currently about 450 employees, of whom 225 possess higher academic degrees and 175 are engineers, technicians, specialists. Four research groups concentrate on semiconductors; three of these groups are under the authority of an Institute Director, Professor Dr. H.J. Queisser. The GaAs project is under the direct supervision of Queisser's new assistant, Dr. W. Rühle, whose last position (before the end of 1985) was in the industrial research and development laboratory of Siemens at Erlangen.

Rühle told me that his research group (which involves a large proportion of visiting scientists, including some from communist countries) currently focuses on the understanding of the physical basis of processes relevant for fast devices. One of the research projects involves the study of the temperature dependence of electron mobility in two-dimensional electron gasses (arising in GaAs/GaAlAs systems). Another effort concerns the effect of the doping strength, and a third studies the question of whether GaInAs is superior to GaAlAs. More general research concentrates on careful measurements of electron-phonon scattering in the two-dimensional electron gas. Impurity and other defect-effects are also looked into. For all these studies, the principal research methodology is based on picosecond laser spectroscopy. The scientists observe various luminescence spectra, both in the wavelength domain and in the time domain. I was impressed by the rich and modern equipment of the laboratories: German commercial gas and solid-state lasers, homemade dye laser systems, French monochromators, Japanese and English streak-cameras, and Japanese microcomputer control systems are available without difficulty.

I also learned that another research group approaches electron mobility problems from the viewpoint of surface physics studies. These relate to the GaAs/GaAlAs interface. In particular, the team members study recombination processes in these interfaces, as well as electron scattering on defects in the interface.

The purpose of this note is to call attention to the quiet but well-funded work of the Max Planck researchers in the GaAs project, and to inform the readers of the seriousness with which the federal West German Government approaches this area.

Paul Roman
5/22/87

PIONEERING SEMICONDUCTOR DEVICE RESEARCH AT STUTTGART UNIVERSITY'S PHYSICS DEPARTMENT

The Physics Department at Stuttgart University is one of the strongest and best supported academic research institutions in West Germany. For traditional reasons, it is subdivided into four "Institutes" (and there are also other, related institutes outside the framework, such as the one on plasma research or the one on radiation physics). Each of the four institutes has several research groups.

In this note I want to draw attention to the Physics Institute Number 4, which, under the vigorous leadership of Professor M.H. Pilkuhn, specializes on semiconductor research and, I believe, in that area is probably the best European university research center.

The general trend of current work is oriented toward the study of very small devices and structures: both in the area of "pure" basic physics understanding of

such systems as well as potentially novel practical devices. (This work, of course, looks toward applications both in microelectronics and also in optoelectronics.) Research is done in five major areas:

- Submicron systems and quantum well structures technology
- Optical communication
- Optical amplification
- Materials technology
- Defects in semiconductors.

The Submicron Technology Laboratory

The pride of this laboratory is a new high-resolution (down to 10 nm) electron lithography machine, the only one of its kind in Europe. This simple-looking but highly sophisticated machine was developed in Japan, and only about 10 copies have been delivered so far (amongst them, one each to AT&T, Bell Laboratories, and the Cornell University microstructures facility.) Its price was over $2.2 million, paid by a grant from the Volkswagenstiftung. With this direct-writing equipment, the researchers can now fabricate not only two-dimensional but also one-dimensional systems, and, they hope, soon they will be able to produce "zero-dimension" structures (where confinement of the electron gas is in all directions). Apart from basic studies on these systems (done mostly by optical and fast laser-spectroscopy methods), experiments are also done that aim at building distributed feedback lasers (where 0.2-nm precision is achieved). Finally, practical research goes also in the direction of building fast devices (like high-electron-mobility transistors with 0.25-μm gates).

The electron lithography machine is supplemented by a large, 400-kV ion-implanter, which is combined with a small molecular beam epitaxy (MBE) chamber (a gift from Siemens). Dry etching equipment (such as for reactive ion etching) and the usual other submicrostructure fabricating equipments are also up to date and abundant.

Optical Communication Components

InGaAs- and InP-based lasers form the focus of this research group. Particularly careful experiments are being done for studying the temperature dependence of the threshold current, and the role of nonradiative (Auger) processes. Much basic work was done on multi-quantum-well lasers, including GaSb/AlSb structures. GaSb avalanche photodiode detectors, as well as photodiodes based on InGaAs, form an area of intensive research.

Optical Amplification

Optical gain studies were begun about a year ago, using both GaAs, GaInAs layers (on InP substrate), and GaSb/AlSb multi-quantum-well heterostructures (well width: 2.5 to 7.0 nm). At this stage, the primary interest lies in the careful measurements that may explain basic properties, such as spectral distribution and temperature dependence. Apparently, it was here in Stuttgart that the first successful observations on optical gain in these systems were made.

The Materials Laboratory

This facility uses liquid phase epitaxy, metal-organic vapor phase epitaxy, and standard vapor phase epitaxy (for InP devices) to construct all kinds of structures, including quantum-well and multi-quantum-well systems. On the practical side, one example: quite a time ago the researchers developed good capabilities to build Gunn diodes for 124 GHz (with a few mW power).

Defect Studies and Other Work

In this area, deep-level defects both in Si and in various III-V systems are investigated. Particular emphasis is given to the observation of recombination at defect sites. A related study focuses on electron-hole plasma generation in GaAs- and Ge-based two-dimensional multi-quantum-well structures. This research neatly balances the semiconductor plasma research at Frankfurt University (see *ESN* 39-6:272-274, [1985]), where the main interest is in II-IV compounds.

Concluding Comments

Since I am not a semiconductor expert, I did not find it advisable to give a detailed account of the truly outstanding research and very high potential of the Institute. In any case, many colleagues will already be familiar with some of these efforts since, naturally, Pilkuhn's people have strong international cooperative research ties, both with Japan and with the US. However, I have a good selection of preprints and recent reprints from the Institute, and would be glad to share them with interested colleagues.

Paul Roman
5/19/87

A GREAT CONVENTION OF GERMAN QUANTUM OPTICS RESEARCHERS IN BERLIN

The West German Physical Society held it vast annual meeting in Berlin,

30 March through 4 April. Nearly 500 oral presentations were given, segregated neatly (as is now traditional) into 10 independent "conventions" of the various Divisions and Associations that make up the Physical Society.

One of the largest of these was the Quantum Optics Association (Arbeitsgemeinschaft Quantenoptik) convention. Almost all speakers represented universities (especially physics departments) or large national basic research laboratories. The quality of the talks was rather high, the meetings were civilized, the interactions very profitable.

A measure of the importance attached to the quantum optics group was that two of the 12 festive plenary session talks of the Physical Society meeting, and three out of the 34 keynote addresses, were given by prominent members of the quantum optics group. In addition, there were 125 invited and contributed papers in the quantum optics sessions--i.e., one-fourth of all talks was in this broad area. No posters in quantum optics were permitted.

The talks were grouped, essentially, as follows:

- Nonlinear optics and nonlinear spectroscopy (three sessions)
- Lasers and laser applications, including laser spectroscopy (nine sessions)
- Ultrashort laser pulses and ultrashort laser phenomena (three sessions)
- Specific quantum effects, bistability, and chaos (three sessions).

A detailed technical report (ONRL 7-011-C) which covers selected presentations in almost all areas is available. The report is organized into the following chapters and sections:

1. Introduction and Scope
2. Special Presentations on Laser Spectroscopy
3. Laser Development
   - General Topics
   - Ultraviolet Lasers
   - Solid-state Lasers
   - Semiconductor Lasers
4. Ultrashort Pulses and Ultrafast Phenomena
5. Nonlinear Optics
6. Optical Bistability
7. Concluding Remarks

A copy of this report may be obtained by marking and returning the back cover of this issue.

Paul Roman
4/6/87

DIRECTORY OF CHINESE MARINE SCIENTISTS PUBLISHED

A supplement to the International Directory of Marine Scientists has been published by the Institute of Marine Scientific and Technological Information, which is located at Tianjin, People's Republic of China. This directory, produced for the Aquatic Sciences and Fisheries Information System of the UN, includes all active marine scientists working in mainland China at the present time. Information from Taiwan has not been included. As in the original Directory, scientists are listed by laboratory, but there is a separate listing by speciality. Since entries are in both Chinese and English, this should be a valuable publication for American scientists interested in oceanography in China. Copies may be obtained from: Ocean Economics and Technology Branch, United Nations, 2 UN Plaza, Room DC 2-2050, New York, New York 10017.

Jerome Williams
5/28/87

COMMUNITY PROGRAMS IN MARINE SCIENCE

On 26 April 1987 The Challenger Society (the oldest British oceanographic professional society) called the UK oceanographic community together to discuss the details of the latest National Environmental Research Council (NERC) announcement regarding Community Programs in Marine Science. It is expected that about £10 million ($16.5 million) per year will be available for the next 5 years or so to support four or five ongoing projects in marine science. This program is designed to support large-scale activities that are more suitable for a "community" effort (i.e., a group of investigators from a number of different institutions) than for that an individual.

Four such programs have been initiated. These are: the North Sea Program, the Biogeochemical Ocean Flux Study, development of the Fine Resolution Antarctic Model, and development of Autonomous Underwater Vehicles.

North Sea Program. The North Sea Program was actually started last year, with an initial planning effort and a choice of major investigators. When the program is in full operation, it will consist of three separate but related efforts. The first will be an attempt to develop a model that will include both

circulation and various other processes of interest, such as those having to do with nutrients, hydrocarbons, and sediments. The second effort will involve a study of the aforementioned processes with laboratory studies supplementing those made in the field. The last portion of the program will consist of a concerted datagathering effort to extend over a 15-month period. Dedicated to this task will be R/V *Challenger*, aboard which currents, salinity, temperature, fluorescence, transmittance, and other items of interest will be measured. In addition, six current meter moorings will be deployed. Although NERC is prepared to go it alone on this in-depth study of an area of interest to a number of countries, it is expected that other countries may offer assistance as the program develops.

Biogeochemical Ocean Flux Study. The Biogeochemical Ocean Flux Study is primarily concerned with the carbon cycle, but since both organic and inorganic cycles include oceanic carbon sinks, the study promises to be a very broad one. This study has been prompted by the marked increase in atmospheric carbon dioxide noted over the last few decades. Only about half of the excess carbon dioxide produced by burning fossil fuels can be found in the atmosphere, but relevant oceanic processes are so poorly understood that the ultimate fate of the other half is not known. It is hoped that improved understanding of many biogeochemical processes will result and that models describing these processes will become available. A request for proposals will go out this summer. Since the American-led GOFS (Global Ocean Flux Study) is well beyond the planning stage, it is expected there will be a sharing of both data and ideas across the Atlantic.

Fine Resolution Antarctic Model. Fine Resolution Antarctic Model is, as the title implies, a pure modeling study. Since a CRAY-XMP computer is now available to British modelers, they can now tackle a large-scale numerical model such as this. The Southern Ocean was chosen for this project because it is different from the rest of the world ocean, its circulation is not too well understood, and the UK has a vested interest there. The plan is to start out with a coarse grid (650,000 grid points) and work toward a fine grid (7,800,000 grid points) using "best guess" data. This project will be used to attract new students and postdocs into modeling, as the better part of the money available will be spent for student and postdoc assistance.

Autonomous Underwater Vehicles. The last in this group of approved projects is Autonomous Underwater Vehicles. In contrast to the other three, this is planned to be strictly hardware oriented. The plan is to design and develop a series of preprogramed, unmanned vehicles, capable of being sent to sea to acquire and store data from preselected stations, at preselected depths. The driving force behind this effort was the belief that the world ocean is undersampled, and additional water column data is becoming more and more expensive to obtain by conventional techniques. In addition, it is hoped that this project will involve British industry so that forward-oriented enabling technology will emerge, and a marine technology industrial base will be developed.

Conclusions

This decision by NERC to fund some oceanographic projects involving a large segment of both the institutional and academic communities, along with some industrial participation, comes at a critical time for the UK. National support of a significant amount, covering broad areas of interest, should go a long way toward improving the image of British marine science both at home and abroad.

Jerome Williams
5/4/87

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two DOD employees for registration-free participants in the conferences ONRL supports. Readers who are DOD employees and are interested in a free registration to one of these conferences should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

5th International Conference on Phase Partitioning, Oxford University, UK, 23-28 August 1987.

7th International Conference on Erosion by Liquid and Solid Impact, Cambridge, UK, 6-10 September 1987.

International Symposium on Turbulent Shear Flow, Toulouse, France, 7-9 September 1987.

International Digital Signal Processing Conference, Florence, Italy, 7-10 September.

7th GAMM Conference on Numerical Modeling in Fluid Mechanics, Louvain-la-Neuve, France, 9-11 September 1987.

Turbulent Drag Reduction by Passive Means, London, UK, 15-17 September 1987.

Engineering Materials for Very High Temperatures, Coventry, UK, 22 September.

ONRL REPORTS

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

Behavioral Sciences

A Free-Response Method of Computer Personality Assessment: A Research Update, by William D. Crano. (7-016-R) The free-response methodology, first reported by *ESN* in early 1984, has been tested and extended, and the results appear to support the high initial expectations. Recent developments in the techniques are reported, and the author discusses means that could be employed to further develop this important measurement method.

Computer Sciences

Research and Development at Centre Swisse d'Electronique et de Microelectronique (CSEM), by J.F. Blackburn. (7-015-R) The principal current scientific and technical activities at this laboratory in Neuchatel, Switzerland. Those activities are: design of integrated circuits and systems, microelectronics technology, development of custom integrated circuits, optoelectronics and peripheral components, and materials and microelectronics. With extraordinary versatility, it is one of Europe's important laboratories.

Material Sciences

Applied Material Science in Turkey, by Louis Cartz. (7-013-R) This report covers visits to several of Turkey's leading technical institutions and provides a survey of some of their facilities and ongoing research in applied material science, primarily with minerals, ceramics, polymers, and elastic constants. The institutes visited included: Middle East Technical University (METU), Ankara; Turkish Scientific and Technical Development Agency (Tübitak), Ankara; Mining Research Institute Ankara (MTA); Tübitak Electronics and Electrical Research Institute, Ankara; Marmara Research Institute, Gebse; and Ankara Nuclear Research and Training Center (ANAEM).

Metal Physics, Université De Poitiers, France, by Louis Cartz. (7-014-R) The microstructure of metals is studied by a range of electron optical methods, grazing incidence x-ray diffraction, and conversion electron Mössbauer spectroscopy. The microstructure is related to mechanisms of plastic deformation, defect formation by ion implantation. Dynamic ion beam mixing reactions are being undertaken and studies of surface treatments and modification of surface properties. Superalloys, various alloys involving Cu, Al, Fe, Cr, Ni, Ti are being investigated as well as various precipitates in metals.

Mechanics

Fluid Mechanics at the Middle East Technical University and the Istanbul Technical University, by Eugene F. Brown. (7-012-R) In surveying the fluid mechanics activity and facilities at two Turkish universities, the author documents the status of the research at these institutions and also reveals the apparent difficulties inherent in the effort to establish satisfactory research activity in a developing country such as Turkey.

Facilities and Research at the French-German Institute of Research at Saint-Louis, by Daniel J. Collins. (7-017-R) The Institute of Research at Saint-Louis, France, is involved in research in ballistics, chemistry of explosives, and detonations, aerodynamics of wings and slender bodies, acoustics, lasers, and measurement techniques. This report is a review of some of the research and facilities.

Ocean Sciences

The International Symposium on Microwave Signatures and Remote Sensing, by Jerome Williams. (7-010-C) Held in January 1987 at Gothenburg, Sweden, this symposium was attended by participants from 16 countries. Discussions covered signatures from snow and ice, solid ground, ocean surfaces, and vegetation and considered systems and radar altimetry, interactions and modeling, and new methods.

Physics

German Quantum Optics Research in the Mirror of the Annual Physical Society Meeting, by Paul Roman. (7-011-C) The 51st annual convention of the (West) German Physical Society, on 30 March through 4 April, in Berlin, hosted the very large meetings of the West German Quantum Optics Association. About 130 talks were presented. Nonlinear optics, nonlinear spectroscopy, lasers, laser applications, laser

spectroscopy, ultrashort laser pulses, ultrashort phenomena, quantum-effects, bistability, and chaos were the session headings. This report covers selected topics from most of these areas. The conference reflected well the work currently done in the academia of the Federal Republic.

OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are reported below. For details, contact the traveler directly.

Chemistry

Traveler: Dr. Daniel Moses, Institute for Polymers and Organic Solids, University of California, Santa Barbara, California 93106.

Dr. Moses participated in the International Winterschool for Electronic Properties of Polymers, which was held at Kirchberg, Austria, in March 1987. His purpose was to learn of the recent developments in that field in Europe and also to present some of his (and coworkers) recent work on transport properties of polyacetylene and polydiacetylene (PDA-PTS). Dr. Moses considered it important to present his results to the European audience because, in his words, "our results as well as our interpretation are markedly different than those of a few groups in Europe that have investigated PDA-PTS for many years."

Dr. Moses states that among the most important new developments is the synthesis route of free-standing films of polyacetylene, free of sp^3 defects, which has been developed by H. Naarmann and coworkers at BASF Laboratories, Ludwigshafen, West Germany. Moses says that, "the room temperature conductivity of these films when doped with iodine is really spectacular: 2×10^5 S/cm--very close to that of copper." The other recent impressive development he cites is the realization of the long sought after applications of the conducting polymers: PDA-PTS have been developed by Allied Signal, Inc., Morristown, New Jersey, as a time-temperature, temperature limit, etc. for *in situ* monitoring of perishable or hazardous packaged products.

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Information on each of the reports listed below was furnished by the activity identified by the abbreviations for that office. Requests for copies of or information about the document should be addressed to the appropriate office:

USARDSG--US Army Research Development and Standardization Group, Box 15/65, FPO New York, 09510-1500
EOARD--European Office of Aerospace Research and Development, Box 14, FPO, New York 09510
AFELM--Air Force Liaison Europe and Middle East, Box 30, FPO New York, 09510

Multidiscipline

Scientific Highlights, (Winter 1986-1987), a quarterly report by the USARDSG. (31 pp) [Request by title from USARDSG.]

This report presents summaries of selected European research and technology transfer projects concerned with a variety of disciplines. The report also includes information on workshops and conferences supported by the USARDSG.

Chemistry

International Symposium on Trends and Applications in Thin Films, by LTC LaRell Smith, EOARD. [Report No. EOARD-LR-87-40/LRP.]

This conference was held in Strasbourg, France, from 17 through 20 March 1987. There were over 300 attendees from Europe, and papers were presented on nearly every aspect of thin films including optics, electronics, magnetics, hard coatings, and analytics. Of particular interest were papers on optical coatings with a very high stability in their optical properties when subjected to temperature and humidity variations (130 to 350°C), thin-film techniques for x-ray mirrors (30 percent

reflectivity), new devices using organic semiconducting polymers on semiconducting substrates, thin-film microbatteries, and materials for ohmic contacts on GaAs and CdTe. A brief report on these papers is available along with a full list of papers presented. Copies of any of the papers can be provided and a few copies of the full proceedings will be available.

Gamma X-Ray Emission Mapping in Chemical Bond Structure, by MAJ Scott Shackelford, EOARD. (3 pp) [Report No. EOARD-LR-87-09/LRC.]

Modifying existing equipment using bent crystal focusing, Professor W. Weyrich, University of Konstanz, West Germany, obtained intense signals of a compound's inelastic energy peak. Peak shape analysis produces a one-dimensional electron momentum map which characterizes one component of chemical bond structure. This gamma x-ray emission scattering technique compliments x-ray diffraction which maps the one-dimensional electron position component. Together, the mapped momentum and position components fully describe chemical bonding structure.

Novel Optical Absorption/Emission Dyes: Synthesis and Mechanisms, by MAJ Scott Shackelford, EOARD. (3 pp) [Report No. EOARD-LR-87-08/LRC.]

Professor E. Daltrorozzo, University of Konstanz, West Germany, has a synthesized group of optical dye compounds with a novel chemical structure and has characterized their fundamental energy transfer mechanisms. These stable high-emission dyes perform in solid, transparent matrix materials; some dyes provide a 100-percent quantum yield and molar extinction coefficients 400,000 M^{-1}/cm^{-1}. His various fluorescence dyes cover the entire UV to IR range (400 to 1000 nm) and have definite potential application to optical storage devices.

Organic Substrate Solubilisation of Water-Soluble Biological Organisms, by MAJ Scott Shackelford, EOARD. [There is no report for this abstract. Additional information can be obtained by contacting MAJ Shackelford.]

Professor P.L. Luissi, Eidgenoessiche Technische Hochschule (ETH), Zurich, Switzerland, has developed a microemulsion technique using reverse micelles to host water-soluble enzymes or microorganisms in organic solvents without significant activity loss. A homogeneous, viscous gel results in which the degree of enzyme/microorganism uptake by the organic solvent is controlled by the micell size. This has obvious biotechnological applications for enzyme catalyzed organic material synthesis. A patent application is pending for blend polymers made from starch (H_2O soluble) and protein (organic soluble) for use as a body-degradeable plastic medicine capsules.

Electronics

Microstrip Antenna Research, by MAJ Mel Townsend, EOARD. (1 p plus research reprints) [Report No. EOARD-LR-87-31/LDE.]

The Weizmann Institute of Science, Rehovet, Israel, has a unique group working in design of microstrip, printed antenna arrays. This group has worked extensively in modeling the boundary conditions of connectors and edge singularities. This excellent theoretical research has been verified by experimentation. Dr. Shtrikman and Dr. Levine of the institute have also designed and built conformal antennas operating at 35 GHz. These conformal antennas (on cylindrical shapes) are designed to operate with high bandwidth and narrow beamwidths (2°). Both single-sided microstrip and doubled-sided dipole-printed antennas have been designed, fabricated, and tested. This report summarizes the group's work and includes copies of research reprints.

Life and Behavioral Sciences

The Perception and Brightness of Color: Neurophysiology, Psychophysics, and Computation, a report under contract FL2878-85-00014 by A.J. Parker, M.J. Hawken, and C.B. Blakemore of the University of Oxford, UK. (37 pp plus appendix and 16 figures) [Report No. EOARD-85-0056 or AFOSR085-0296.]

Progress in research in three areas of computational visual neuroscience is summarized. The first project has assessed the receptive field organization of neurons in the primate striate cortex. A new model is proposed for cortical receptive fields based on linear combinations of difference-of-Gaussian functions. A detailed study of the evidence leading to this conclusion is provided in the attached preprint of a paper which will appear in *Proceedings of the Royal Society of London* 231 (July 1987). The second project is directed towards measuring the chromatic properties of

cortical cell receptive fields. The third project is assessing current computational models of the perception of three-dimensional surfaces using psychophysical techniques with human observers.

Meteorology

Studies of Electro-Optical Attenuation in the Vicinity of Cloud Base, a report under contract AFOSR 85-0229 by John Latham, The University of Manchester Institute of Science and Technology, UK. (17 pp plus 91 figures) [Report No. EOARD-TR-87-4.]

Data is reported of 1986 cloud measurements of cap cloud on Great Dun Fell. PMS FSS probe measurements of particle size distributions from 0.5 to 47 micron radium were obtained. Barnes transmissometer measurements were made of cloud extinction in three spectral bands. Theoretical extinction coefficients will be derived from droplet spectra detected by PMS FSS probe. More extensive analysis will be reported later as a doctoral dissertation.

The Stability of Atmospheric Fields Induced by Localized Topography and Heat Sources, a report under contract AFOSR-83-0069 by Lee-Or Merkine, Department of Mathematics, Technion-Israel Institute of Technology, Haifa, Israel. (61 pp) [Report No. AFOSR-83-0069-004. Inquiries should be directed to Mr. Owen Cote, EOARD.]

In slightly viscous, rotating, stratified systems weak potential vorticity sources can excite finite amplitude response when the group velocity of the long waves vanishes. This mechanism is used, in a two-layer fluid, to generate steady-state solutions that can be characterized as currents. The currents are strongly sheared in both the vertical and the meridional directions but they vary slowly in the zonal direction. Numerical simulations reveal that the currents are unstable with respect to small perturbations and that the unstable response is dominated by trapped eigenmodes. A WKB analysis jointly with a second-order turning point problem are used to derive a consistent description of the spatial and temporal characteristics of the unstable eigenmodes. The stability analysis is applicable to zonally varying basic states that are stationary with respect to zonal variations at some isolated points of the flow domain.

Mechanics

Experimental Boundary Layer Work, by LTC Bob Winn, EOARD. (2 pp) [Report No. EOARD-LR-87-30/LDV.]

The aeronautical engineering group at Israel's Tel Aviv University which is headed by Professor Wygnanski is a leader in experimental studies of boundary layer transition. They recently discovered a smooth but porous material which they will use to precisely control the size of the boundary layer in their wind tunnel. They speculate that one could eliminate the need for drag-processing control surfaces by using this material on the surfaces of aircraft or submarines. This short report briefly describes their work and identifies the key researchers.

US/European Vortex Flow Experiment Test Report of Wind Tunnel Measurements on 65° Delta Wing in the NLR Supersonic Facility SST, a report under contract AFOSR 86-0267 by Simon J. Boersen, National Aerospace Laboratory (NLR), the Netherlands. (41 pp) [Report No. NLR TR 86117L. Address inquires to LTC Winn, EOARD.]

An investigation was carried out in the NLR wind tunnel SST on the AFWAL 65° delta wing, equipped with both a sharp and a rounded leading edge. Force and pressure distribution data were obtained at free-stream Mach numbers of 1.31; 1.72; 2.18; 3.02; and 3.94. The incidence was limited to approximately 15° at the low supersonic Mach numbers and to 6° at the free-stream Mach number from 15×10^6 to 42×10^6. At 5 Mach/alpha conditions surface flow pictures were produced using an oil-flow technique. During all pressure measurement runs Schlieren photographs were taken. Tabulated results are set on microfiche; a copy is included in this report.

Physics

Magneto Plasma Dynamic Propulsion, by Dr. Stacey Lazdinis, EOARD. (2 pp) [Report No. EOARD-LR-87-17/LRL.]

The Institut für Raumfahrtsysteme at the University of Stuttgart, West Germany, is performing both basic and applied research in magneto plasma dynamic propulsion, plasma physics, chemical propulsion, and turbomachinery fluid dynamics. The organization's very impressive facilities are to be used to perform thermal testing of the tiles for the European Space Shuttle, Hermes.

Structures/Structural Materials

Polymer Matrix Composite Research, by LTC Jim Hansen, EOARD. (2 pp) [Report No. EOARD-LR-87-24/LDS].

The Dupont Corporation is sponsoring an effort led by Professor Gad Marom of the Hebrew University, Jerusalem, Israel to determine by modeling how variations of the diazoncyanide interlayer affect composite properties. In another project, fatigue and wear of hybrid composites will be studied in a joint research project between a German and two Israeli universities. Materials to be tested include carbon, aramid, glass and Kevlar fibers, epoxy matrices, and varying-strength interfaces.

TECHNOLOGY ROUNDUP--ITALY

The items below were received from the American Embassy in Rome. For further information, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-0007.

Funds Requested for R&D in Biotechnology. The Italian Minister for Scientific Research Transmitted to the Interministerial Committee for Economic Planning (CIPE) a L400 billion request (~$300 million) for the national research project on biotechnologies. The 5-year project will commence in 1988 and will involve the National Research Council and other Public Research Centers as well as much of the Italian biotechnology industry.

Funds Requested for Building Technologies. The Italian National Research Council submitted to CIPE for approval a new "finalized project" on building technologies. The project, budgeted at L121 billion (~94 million) for 5 years, will center on processes and procedures ($10.5 million), innovation ($47.8 million), and quality control ($35.7 million). This project parallels the national plan for research on buildings, already launched by the ministry of scientific research. While the latter will cater more to industry and industrial innovation, the former will concentrate on basic and applied research.

Development of High-Performance Optical Guides Announced. The Turin-based Center for Studies and Laboratories for Telecommunications (CSELT) of the IRI/STET group announced the development of high-performance optical guides under an EEC/ESPRIT optical fiber research project. The CSELT optical guides are made of gallium, aluminum, and indium arsenides with an attenuation of the optical signal equal to 2.2 dB/cm, making the optical guides among the best of their kind.

CNR Demonstrates Superconducting Material. The Italian National Research Council (CNR) demonstrated at the Milan fair new superconducting materials developed by the CNR's institute for material technology. The demonstration consisted of superconductivity tests of YBBCO at -179.5°C (93.7 K). CNR President Rossi Bernardi said CNR will accelerate financing for the new finalized research project on superconductivity. Meanwhile, the Agency for Nuclear and Renewable Energies (ENEA) and the Agency for Electricity (ENEL) stated their decisions to enter fully into competitive superconductivity research.

EMBASSY NOTES FROM WEST GERMANY

The items below were received from the American Embassy in Bonn. For further information, contact Dr. Edward M. Malloy, Office of the Science Counselor, American Embassy, APO New York 09080.

West Germany Announces Development of 4-Megabit Chips. With substantial support from the West Germany and Dutch governments, Siemens and Philips have developed a 4-megabit memory chip, billed here as the superchip. Development of the chip, including the installation of the production line, will cost DM3.4 billion ($1.85 billion). The Federal Research Ministry reportedly funded the project with DM340 million ($185 million), which corresponds to approximately 40 percent of the development costs, and the Dutch government funded DM160 million ($87 million).

According to the West German Federal Minister of Research and Technology, Heinz Riesenhuber, the development of the 4-megabit super-high integrated storage chip is an important milestone on the way towards reaching Japanese and even American standards in the chip development by the year 1988. The superchip has a size of 91 square millimeters and a corresponding storage capacity of 250 normal letter-size pages.

In its daily press service, the Federal Parliamentary Caucus of the Social Democratic Party (SPD) praised the development of the superchip as evidence of the capability of German scientists and engineers to match the leading nations in high technologies and as an important step towards Europe's independence. Less positive was the conservative *Frankfurter Allgemeine* which raised the question why such developments need governmental subsidies to be successful.

New Secretary General for West Germany's Max Planck Society. On 1 May 1987, Dr. Wolfgang Hasencleaver left his post as Deputy Chairman of the German Aerospace Research Establishment (DFVLR) to become Secretary General of the Max-Planck Society (MPG). The MPG, sited in Munich, is the umbrella organization of 58 Max-Planck Institutes.

At DFVLR, Hasenclever promoted many far-reaching multilateral decisions representing milestones in the development of the DFVLR, which is the largest German Research Institution. He was also involved in participation of the DFVLR in numerous international projects.

Hasenclever was strongly committed in the realization of the European transsonic wind tunnel (ETW) project, which is planned for construction on the site of the DFVLR headquarters in Cologne/Porz-Wahn and which is scheduled for start of operation in the mid-1990's. This wind tunnel is designed for operating at low temperatures and for providing high-precision fluid measurements at cruising speeds of civil aircraft.

Hasencleaver has said that he looks forward to developing close ties with the US National Science Foundation as well as with US Scientific Institutes and Universities.

JUNE MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during June. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the *Bulletins*, by number, from ONR, London.

Number	Title
19-87	Nowcasting--Weather Information, Frontiers Style
20-87	ERS-1's Along-Track Scanning Radiometer (ATSR)
21-87	Expendable Torpedo Countermeasure Device for UK

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